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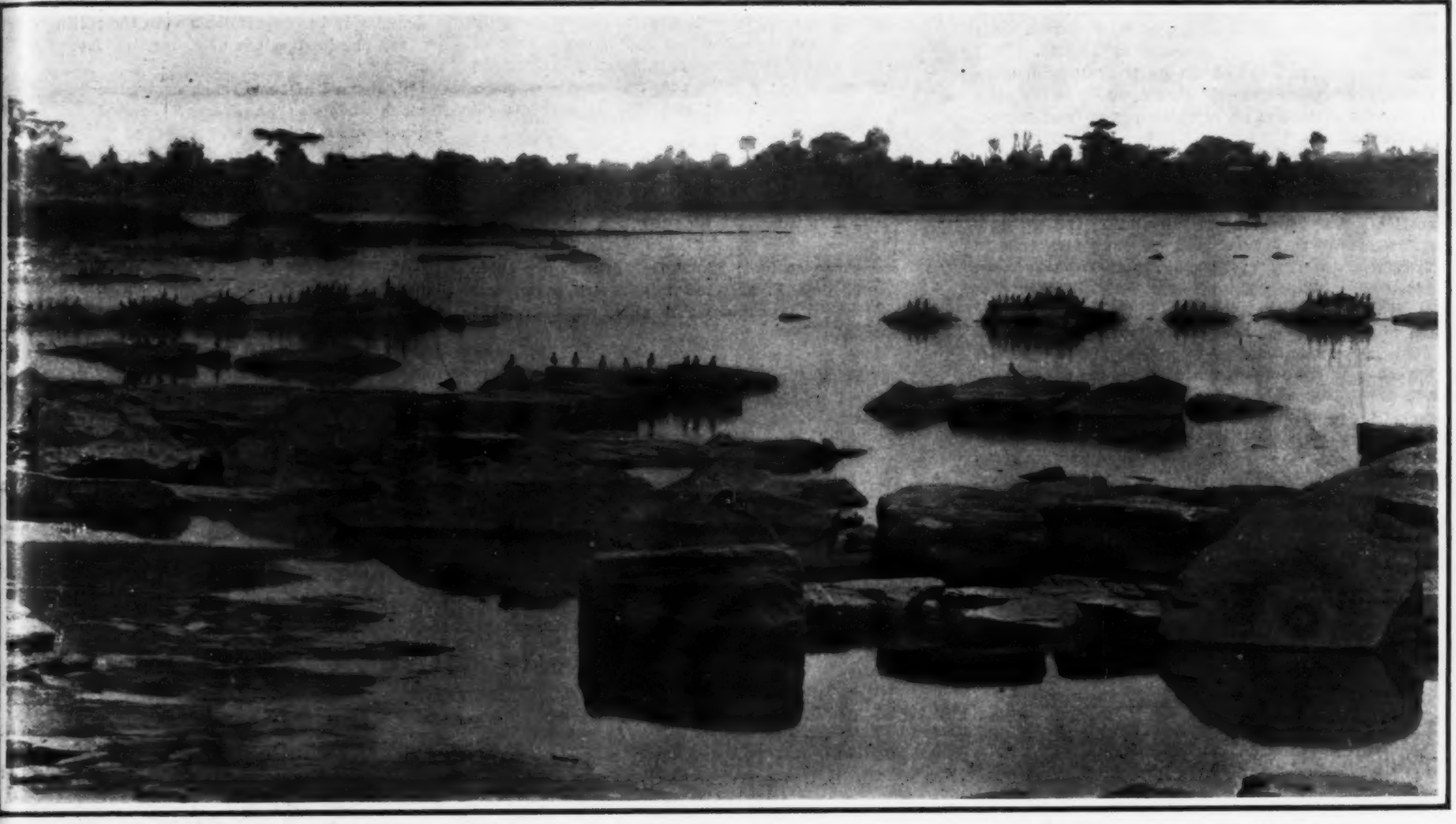
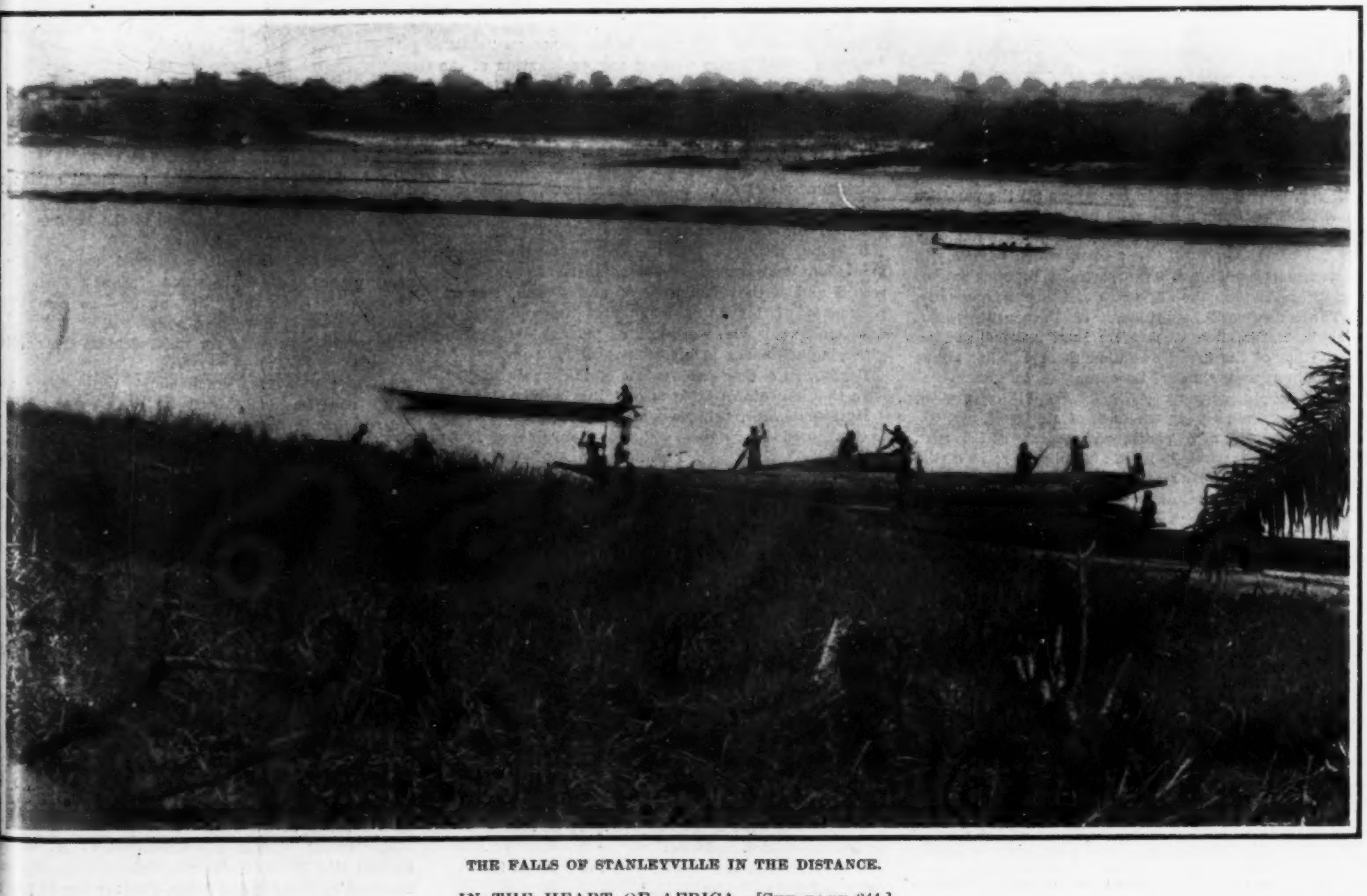


IN AUGUST GREAT FLOCKS OF PLOVER-LIKE BIRDS, GLAREOLA, SIT ON THE SAND BARS AND STONE LEDGES OF THE UPPER CONGO.



THE FALLS OF STANLEYVILLE IN THE DISTANCE.

IN THE HEART OF AFRICA.—[SEE PAGE 344.]

PRACTICE AND THEORY OF AVIATION.—VI.[*]

THE LEADING AEROPLANES.

BY GROVER CLEVELAND LOENING, A.M.

Continued from Supplement No. 1820, page 334.

The Present Status of Theory Relating to Mechanical Flight.

Part A. The Resistance of the Air and the Pressure on Normal Planes.

Although the fact that air has inertia is a familiar one, the important deductions to be drawn therefrom, were not fully recognized until the classic experiments of Langley exhibited them in their true import.

The resistance of the air in its bearing upon aeronautics, and especially in the consideration of the pressure on the surface of an aeroplane, is of fundamental importance.

Many values and methods of determining air resistance have been suggested, but they differ widely from each other. Because of this, designers of aeroplanes experience great difficulty in calculating the probable performance of their machines. A small difference in the value of the "constant of air resistance" may mean an over or under estimation of a certain pressure to the extent of several pounds, which in turn may involve added expense and decreased efficiency.

It is therefore desirable to investigate the present knowledge on the subject, not so much for the purpose of theoretic discussion as to arrive at some definite and conclusive values of the various quantities involved that will be of use to the engineer.

Sir Isaac Newton, in Section VII, Bk. II, of the Principia, treats "of the motion of fluids, and the resistance made to projected bodies." He defines air as an elastic, non-continued, rare medium, consisting of equal particles freely disposed at equal distances from each other.

Thus if we represent by A B the section of a surface against which a stream of air is flowing, then the particles of air, according to Newton, impinge directly against the surface, as indicated by the small arrows in Fig. 1.

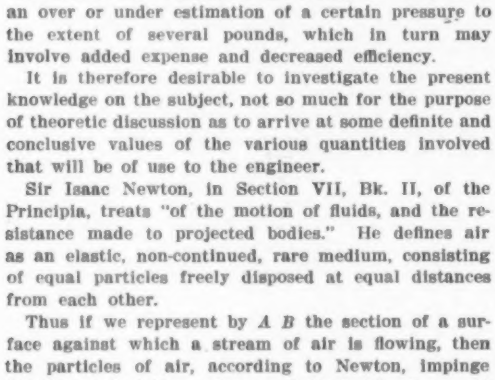


Fig. 1.

In contrast to this Newton defines water, quicksilver, oil, etc., as continued mediums, where all the particles that generate the resistance do not immediately strike against the surface. The surface is pressed on only by the particles that lie next to it, which particles in turn are pressed on by the particles beyond, and so on. Fig. 2 shows the character of this fluid pressure.

The subsequent experiments of Bernouilli, Euler, Robins, Borda, Bossut, and De Buat showed the imperfection of the first Newtonian theory. That air as a medium was similar in character to water was shown conclusively by the photographic results of the experiments on stream lines of air by Marey.

The resistance of a "continued" medium of this sort, according to Newton, is in the "duplicate ratio of the velocity" and directly as the density of the medium.[1]

Navier derives a similar relation.[2]

Robins in 1746, with a view to determining the resistance of the air to cannon balls, whirled planes and spheres about a circular orbit, and found that the resistance varied directly as the square of the velocity.

In 1791 Col. Beaufoy carried on a series of experiments, the results of which were published later in connection with the Swedish tests of Lagerhjelm in 1811, and showed also that the pressure varied as the square of the velocity.[3]

Rennie in 1830 abundantly verified this relation for low velocity and it can be accepted as true.[4]

In other words, if we express by P the pressure on a surface of area S, generated by an air stream of velocity V, then

$$P = K\ S\ V^2 \text{.............................} (1)$$

Where K is a constant of figure involving the density of the air and depending on the barometric pressure, the temperature and the character of the surface and usually termed the "constant of air resistance."

This equation may be derived from the laws of mechanics.

If we let W = the weight of air directed against any normal surface in a given time; w = the weight in pounds of one cubic foot of air; V = the velocity of the air stream in feet per second; S = the area of the surface on which the pressure acts; M = the mass of air of weight W; g = the acceleration due to gravity = 32.2 feet per second^2; and P = the pressure on the area S.

Then $W = w\ S\ v$

The momentum of the force on the area $= M.v = \dfrac{W v}{g} = \dfrac{w}{g} . S\ v^2$.

If $S = 1$ square foot; $w = 0.0807$ pounds per cubic foot for 32 deg. F. and 760 millimeters barometric pressure; and V be expressed in miles per hour, then since $P = M.v$

$P = .0054\ V^2$

K thus taking the theoretical value 0.0054, where V is expressed in miles per hour and P in pounds per square foot. This system of units will be used throughout this discussion.

In 1759 John Smeaton, in discussing some experiments of Rouse, deduced the formula $P = 0.005\ S\ V^2$, and considering S unity he published a table of the velocity and pressure of wind, as follows:[5] The correct Smeaton value for K is 0.00492, but it has become customary in engineering practice to take it as 0.005.

TABLE V.

Velocity. Miles per Hour.	Pressure, Lbs. per Sq. Ft.	Velocity, Miles per Hour.	Pressure, Lbs. per Sq. Ft.
1	.005	40	7.873
2	.020	45	9.963
3	.044	50	12.30
4	.079	55	14.90
5	.123	60	17.71
10	.492	65	20.85
15	1.107	70	24.10
20	1.968	75	27.70
25	3.075	80	31.49
30	4.429	100	49.2
35	6.027		

Smeaton adopted this table in his paper on "Mills" from his friend Rouse without any explanation of the kind of experiments from which it had been formed.

Rouse had based his results on a statement by Mariotte, which he verified by his own experiment consisting of whirling a 3 square foot plane in a circular orbit of only 30 feet circumference and at a maximum velocity of 8 miles an hour. Rouse assuming that the resistance varied as the square of the velocity, laid down the law that $P = 0.005\ V^2$.

Smeaton, although misinformed as to the experiments of Mariotte, proceeded to make use of these results and of the constant 0.005 and without any experiments of his own, formulated the well-known Smeaton Table, which appears as standard in the engineering textbooks of all countries.

Bender, in a thorough review of the whole subject, says that Smeaton's table is certainly unreliable.[6]

Hutton in 1787, using a whirling apparatus similar to that used by Robins, deduced the value of K as 0.00426.

The experiments of Didion on falling plates of 11 square feet area in 1837 established $K = 0.00336$, and later experiments by him, the results of which were published in 1848, showed conclusively that the resistance of the air was directly proportional to the square of the speed.[7]

Col. Duchemin in 1842 conducted experiments on the resistance of fluids which are in many ways remarkable. He investigated the subject very thoroughly and his work is standard. The value of K he derived as 0.00492.[8]

Poncelet, who also did much work in this line, obtained the value of $K = 0.00275$.[9]

Hagen in 1860 obtained the value $K = 0.00292$, and Recknagel in 1886 got the value 0.00287.[10] These experiments were all thorough, and the surfaces were moved in a straight line.

Thibault in 1856 and Goupil in 1884 derived a theoretical value of $K = 0.0053$.[11]

Lord Rayleigh also considered the subject theoretically and deduced $K = 0.0055$.[12]

Experiments similar in character to the recent ones of Eiffel were conducted in 1892 by Cailletet and Collardeau and K was found to be 0.0029.[13]

Dr. Pole in 1881 deduced $K = 0.0025$, and at some length discussed the absolute unreliability of Smeaton's table.[14]

Langley in his experiments with the rolling carriage in 1888 obtained values of K ranging from 0.00389 to 0.00320.[15]

Col. Renard of the French army, the builder of the famous dirigible "La France," carried out extensive experiments on planes and shapes of "least resistance" in 1887, and deduced the value of $K = 0.00348$.[16]

Canovetti in the elaborate experiments conducted by him on inclined railways at Brescia and Brunate in Italy during 1901, determined the value of K as 0.0029.[17]

The most recent and complete experiments on the resistance of the air were conducted by Eiffel in 1903 and 1905. He recognized two sources of inaccuracy—the neglect of the consideration of the separate air filaments which vary at different points on the surface, and the cyclonic motion of the air, due to a revolving source. The experiments were conducted on the Eiffel tower, and the surface was attached to a carriage by springs, the pressure being recorded on a blackened cylinder. The carriage was allowed to fall vertically about 312 feet, and was constrained in its motion by a vertical cable.

The coefficient K varied remarkably little and was practically determined as 0.0031.[18]

Many other values of K have been determined.

Prof. Allen Hazen in 1886 deduced $K = 0.0034$.[19]

Dines in 1889 obtained the value 0.0035.[20]

Lilienthal[21] and Von Loessel[22] determined K as 0.13 in metric units or 0.005 in English units.

In 1890 C. F. Marvin at Mount Washington, N. H., where it is said winds as high as 150 miles per hour were observed, got K as 0.004.

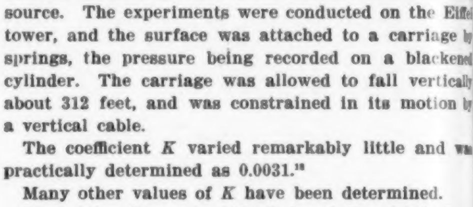


Fig. 2.

T. E. Stanton determined K for small surfaces at 0.0027.[23]

The Voisin brothers, builders of the famous biplane, derived a value of $K = 0.0025$.[24]

The Wrights in 1901 conducted experiments on small planes and got the value of K as 0.0033.

Other formulæ than the one now so generally in use (formula I) have been suggested.

Canovetti lays down for unit surfaces the empirical formula:

$P = 0.0324\ V^2 + 0.432\ v$ (in metric units) as a result of his experiments.[25]

Experiments conducted by Morin, Piobert, and Didion in France about 1837 indicated that

$$p = 0.0073 + 0.0034\ V^2.$$

Soreau in 1902 proposed a formula which for small velocities shows the pressure to vary as the square of the velocity and for higher velocities as the cube.[26]

Renard had previously pointed out that the general formula

$$P = K\ S\ V^2$$

was bad for either very low or very high velocities.[27]

Zahm, in measuring projectile resistances, found the pressure to vary as the cube of the velocity for high speeds.[28]

Eiffel found that between 18 and 40 meters per second the pressure was proportional to the square of the velocity, and at speeds above 33 meters per second it already began to increase and vary as the cube. It is hardly probable, however, that aeroplanes will ever reach velocities where the pressure will vary other than sensibly as the square.

Interesting experiments conducted by A. R. Wolff showed that K for 45 degrees Fahr. was equivalent to Smeaton's value, that at 0 deg. Fahr. it was 10 per cent

* Accepted as thesis for the degree of A.M., Columbia University, June, 1910.

greater, and at 100 deg. Fahr. 10 per cent less.[29]

Langley, in considering the effect of temperature on density, expresses the relation between pressure and velocity for unit surface in the form,

$$P = \frac{KV^2}{1 + 0.00366\,(t - 10 \text{ deg.})}$$

where 0.00366 is the coefficient for expansion of air per degree C., t = temperature of the air in degrees C., and K is expressed for 10 deg. C. in metric units.

Prof. Kernot in experiments conducted on the Forth Bridge found the average pressure on large surfaces such as railway coaches, houses, etc., never exceeded two-thirds of that upon a surface of 1 or 2 square feet.[30] The variable density of air puffs, whirls, etc., would account for this, and probably the maximum intensity of pressure is confined to small areas.

Borda, Hutton, and Thibault found from their researches that the resistance increased with the absolute size of surface, while Dines holds a contrary opinion. Von Loessl's experiments showed that small and large surfaces experience resistance simply proportional to their sizes.

Most of the experiments cited thus far have been conducted on planes and shapes of very small size, and show large discrepancies.

The method of experimenting by use of a whirling table is unquestionably inaccurate, because the air in the vicinity of the apparatus is itself set in a rotating motion.

Most of these results, therefore, because of the inadequate character of the apparatus cannot be conclusively applied to the case of an aeroplane in flight.

Those experiments conducted in a straight line, however, more nearly resemble the actual conditions, and it need hardly be pointed out that the character of the air resistance to a fast moving train resembles much more the resistance experienced by a full sized aeroplane in flight, than any other of the methods used.

Numerous and excellent experiments on the resistance to trains have been conducted.

Mr. Scott Russell as early as 1846, in discussing the resistance of the atmosphere to trains, stated that the results of his experiments showed that the pressure according to Smeaton's Table was almost double the actual pressure on a plane and that the formula $p = 0.0025\ S\ V^2$ was correct.[31]

In 1901 J. A. F. Aspinall in experiments on trains carefully measured the air resistance by pressure gages, and found $K = 0.003$. In his paper on this subject previous experiments are discussed very thoroughly, and in the fifty-five different formulæ and experiments on the resistance to trains that he cites, the large majority of them make use of values of K below 0.003.[32]

The most recent and accurate results in this line are given by the experiments on air resistance conducted during the tests of the high-speed electric trains on the Berlin Zossen Railway in 1903.[33]

The velocities attained were as high as 110 miles an hour, and the air resistance was carefully measured by an elaborate set of accurate pressure gages.

The results were plotted on a large chart and the mean value of the observations showed that

$$P = 0.0027\ V^2.$$

These experiments are undoubtedly the most accurate and the best applicable to the actual conditions of a large body moving through the air at high speed, that have ever been conducted, and show conclusively that the values of air pressure as originally formulated by Smeaton are very seriously at fault.

There are then to be distinguished two main methods of determining K, one by a rotational apparatus and the other by movement in a straight line.

In the following tables experiments according to these two systems are separately grouped, and the values given are weighted, according to the completeness of the experiments, the accuracy, the time, whether very old or very recent, and the size of apparatus used. Mean values, and weighted mean values are then obtained. It must be borne in mind that the object of this investigation is to derive a working value of K applicable to full sized aeroplanes, and therefore experiments conducted on large surfaces are weighted more than those on small ones.

TABLE VI.

Values of K as Determined by Rotating Apparatus.

Name.	Year.	Value.	Weight.
Rouse	1758	.00500	1
Hutton	1787	.00426	4
Duchemin	1842	.00492	6
Hazen	1886	.00340	4
Renard	1887	.00348	8
Langley	1888	.00389	9
Dines	1889	.00350	7
Lilienthal	1889	.00500	7
Marvin	1890	.00400	5
Loessl	1899	.00530	5

Mean value .... = 0.004275
Mean weighted value ...... = 0.00421

TABLE VII.

Values of K as Determined by Straight Line Motion.

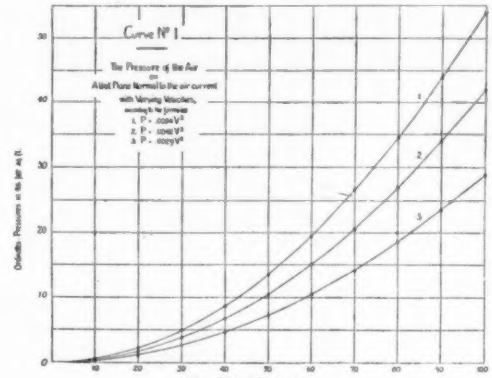
Name.	Year.	Value.	Weight.
Didion	1837	.00330	6
Poncelet	1840	.00275	5
Russell	1846	.00250	3
Hagen	1860	.00292	5
Pole	1881	.00250	4
Recknagel	1886	.00287	6
Cailletet	1892	.00290	7
Canovetti	1901	.00290	8
Wright	1901	.00330	8
Aspinall	1901	.00300	9
Stanton	1903	.00270	8
Zossen	1903	.00270	10
Eiffel	1905	.00310	8
Voisin	1907	.00250	4

Mean value .... = 0.00285
Mean weighted value .... = 0.00290

Grouping these results three distinct values of K are arrived at:

(1) $K = 0.0054$ (By theory).
(2) $K = 0.0042$ (By rotational apparatus).
(3) $K = 0.0029$ (By movement in a straight line).

For the purposes of calculations of pressures on an aeroplane value (3) is unquestionably the most correct one.



CURVE NO. 1.

These results are graphically represented in Curve 1, which shows the great difference in the theoretical value of air resistance and value (3) very strikingly.

We may therefore conclude that for calculations of air pressure as applied to aeroplanes, the most practical expression of such pressure is

$$P = 0.003\ S\ V^2$$

where $K = 0.003$.

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(To be continued.)

A huge railway project, backed by extensive New York capital, for the construction of a railway which will traverse the entire length of Alberta, from the international boundary to Peace River, a distance of 700 miles, and which will be connected with the Hill system in Montana, has just been submitted to and approved by the Alberta government. Work on the first hundred miles has already begun.

BRIQUETTING OF IRON ORES

BEFORE the Iron and Steel Institute, Mr. C. De Schwartz read a paper on the briquetting of iron ores. He pointed out that while the use of improved explosives for mining, and the transit of the ore over long distances, tend to increase the percentage of dust in iron ores, yet the modern blast furnace more and more requires an ore free from dust, owing to its greater height, the high pressure of the blast, and the use of blast-furnace gas for gas engines. The conditions for successful briquetting are: (1) The briquettes must resist a pressure of 2,000 pounds per square inch, and when dropped from a height of 10 feet on to an iron plate they must not fall into dust although they may break. (2) Heated to 900 deg. C. they may begin to sinter, but must not disintegrate. (3) They should not soften when placed in water. (4) They must resist the influence of steam at 150 deg. C. without crumbling. (5) They must be sufficiently porous to absorb 15 per cent of water in 25 minutes when placed in water after drying. (6) Binding material should not contain sulphur or arsenic so as to be deleterious to the pig iron produced. (7) The cost of briquetting should not exceed the difference in price between lump ore and fine ore. *Briquetting without a binding medium*: At Kertsch, in Russia, bean ore is mixed with 8 per cent of water and then pressed at 5,600 pounds per square inch. At Ilsede, in Germany, clay iron ore is mixed with the waste from the washing plant and rolling mills and pressed into briquettes at 4,000 pounds per square inch. In Sweden, the Gröndal process is producing 300,000 tons of briquettes per year at a cost of 4s. 8d. per ton. In this process the ore containing 27 to 58 per cent of iron, and from 0.03 to 1.60 per cent of sulphur, is broken up and then ground in a ball mill; from this powder, by means of magnetic separators, a concentrate of pure magnetic ore is obtained containing 70 per cent of iron and from 0.015 to 0.17 of sulphur. The concentrate is made into briquettes with round edges and heated with generator and blast-furnace gases, in a furnace supplied with hot compressed air by a Körner blower, whereby an oxidizing flame is produced, which converts the magnetic ore (Fe_3O_4) into ferric oxide (Fe_2O_3) and reduces the percentage of sulphur. The finished briquettes contain from 65 to 69 per cent of iron and 0.003 to 0.01 of sulphur and are more easily reduced and require less fuel in the blast furnace than magnetic ore. *Briquetting by means of a binding medium*: Lime and basic slag are not extensively used owing to the diminution of the iron content, and the space and labor required for stacking the briquettes while the lime is being converted into calcium carbonate. Very good but expensive briquettes can be made from spathic ore by mixing with lime and subjecting to steam pressure, calcium carbonate and hydrated ferrous oxide being produced; the latter is gelatinous and becomes oxidized to hydrated ferric oxide. In the Schumacher process, blast-furnace flue dust has its hydraulic properties increased by the addition of magnesium chloride, the cost of briquetting being 1s. 9d. per ton without royalty. Waste sulphite cellulose lyes previously concentrated into a syrup, or cellulose pitch, have been used but are very costly. For use with the ferriferous residues of the aniline manufacture, containing 67 per cent of iron, molasses has been tried, the cost being about 3s. 9d. per ton of briquettes. The Kertsch and Ilsede methods appear to be the cheapest, the cost amounting to only one shilling per ton of briquettes.

A box for a blue print paper roll, arranged to be light-tight, and to allow the paper to be taken out without opening the box, was recently described in the American Machinist. The box is made of ¾-inch mahogany. The cover, which is not hinged, has a ⅝-inch by 1⅞-inch lip, that fits down over the case on all sides. This and a felt pad under the cover exclude light. Secured with screws to the bottom edge of the front panel is a horizontal brass plate 1/16 inch thick and 1¾ inches wide. Between this plate and the bottom board is a space equal to the thickness of three sheets of drawing paper. A recess ¼ inch wide and 5/16 inch deep is cut with a circular saw in the bottom board just at the edge of the horizontal brass plate. The paper is drawn out of the box under this plate, and is cut off by drawing a knife along the edge of the plate, bearing down into the recess. A 3/16-inch pressure bar for holding the paper while cutting is placed 3½ inches in front of the recess. The tracing is started under this bar at the same time as the blue print paper, and thus the proper length of paper is measured. The inside is given four coats of black varnish, made of shellac, lampblack, and varnish. The ends, sides, and bottom are securely put together with glue and screws, and in each corner is a leather fillet. The outside of the case is finished in the plain wood.

WIRELESS TELEGRAPHY AND TELEPHONY.

A REVIEW OF ETHEREAL SIGNALING METHODS.

BY CORNELIUS D. EHRET.

This paper is a brief review of the art commonly known as "wireless telegraphy"; and deals with only one branch of the general subject, that is, with wireless telegraphy and wireless telephony which employ as the energy transmitted through space from the sending to the receiving station what are commonly known as "Hertzian oscillations" or "Hertzian waves," or "electro-magnetic waves," all being synonymous.

There are other systems of wireless telegraphy and telephony which will not be considered, because, so far as the author knows, they have not come into any

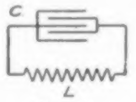


Fig. 1.

extensive commercial or general use; that is, the "earth shunt" and simple "induction" systems.

Had this paper been written ten years ago it might well have gone into greater detail than will be the case now, because at that time the art was quite restricted as compared with the present time.

Fundamentally, wireless telegraphy and telephony depend upon a wave propagation through the ether, the energy having electric and magnetic components, and with a frequency so high as compared with ordinary alternating currents as to denote the energy as "high-frequency waves or oscillation." To give an idea as to the position in the whole category of ether waves of those employed in wireless telegraphy and telephony, the following is submitted:

X-Rays—not visible to human eye; ultra-violet light; frequency 870 trillions to 1,500 trillions per second.

Light—visible to human eye; frequency 430 trillions to 740 trillions per second, less than one octave.

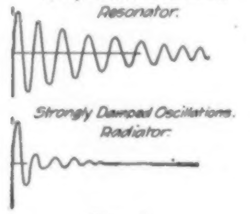


Fig. 2.

Infra red—invisible; frequency 430 trillions down to 300 trillions per second.

Heat—frequency 300 trillions down to 20 trillions per second.

Electro-magnetic waves (Hertzian waves or oscillations)—forty-five octaves lower; frequency of several millions per second down to 100,000 or less per second; used in wireless telegraphy and telephony; 300 feet (or less) to 5,000 feet (or more) in length.

Sound waves (audible to human ear)—frequency of 40,000 per second down to 32 or 16 per pound.

From this table it will be seen that the waves used in wireless telegraphy and telephony have a frequency much lower than light waves, and, indeed, far lower even than heat waves, being just above sound waves in

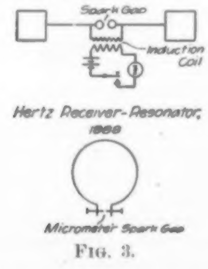


Fig. 3.

the table. And it will be understood that the frequencies under consideration range from about a million per second to one hundred thousand, or less, per second.

The earliest known way of producing high-frequency electric waves, and the way that is in common use, consists in letting loose through a sufficiently low resistance path a charge of electricity, which, when the resistance of the discharge path is sufficiently low, oscillates or swings electrically like a pendulum, there being a decrement in the amplitudes of the successive waves causing them to die out sooner or later, as a pendulum will come to rest after a time.

To consider an elemental case, refer to Fig. 1. Consider the condenser C connected in circuit with the inductance L. The condenser, as is well known, consists of two conducting plates or armatures separated by a dielectric medium, as air, gas, or what not. The inductance consists of a coil of wire, for example (preferably without iron core for high-frequency work), and is a means for lending magnetic inertia to the circuit. If the condenser C has been charged from any suitable source of electricity, it will discharge through the circuit containing itself and the inductance L. The charge will swing first one way and then the other, back and forth, at high rate, gradually dying out owing to radiation of energy from the circuit and owing to resistance and other losses in the circuit.

The frequency of the oscillations so produced is dependent upon the capacity of the condenser C, the magnitude of the inductance L, and the resistance of the circuit. The resistance of the circuit should be

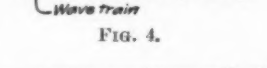


Fig. 4.

made as low as possible consistent with other requirements; and when below a certain critical value oscillations take place, and when the resistance is made low, it may be disregarded as a factor in the determination of the natural frequency of the circuit.

The natural frequency of the circuit may then be expressed as follows:

$$N = \frac{1}{2\pi\sqrt{LC}}$$

N being the number of complete cycles per second, L the inductance, and C the capacity of the circuit. It is evident that N will be greater as either L or C, or both, is or are smaller. This shows algebraically that for high-frequency work inductances and capacities employed are quite small as compared with those used in ordinary alternating-current commercial work.

The speed or velocity of propagation of the energy of Hertzian or electro-magnetic waves through space is the same as that of light, namely, 186,000 miles per second. Knowing this, and knowing also the frequency, N, the wave length is easily computed from the expression

$$V = N\lambda$$

where V is the velocity of propagation, N the frequency, and λ the wave length.

The high-frequency oscillations may be graphically represented as in Fig. 2. Distances measured horizontally represent time, while those measured vertically represent amplitude or intensity. The upper part of the figure illustrates a slightly damped train of waves or oscillations, and are such as may be produced by what is termed a resonator. In the lower half of the figure is shown a train of strongly damped oscillations which die out very quickly. Such oscillations exist in a good radiator, it being characteristic of a resonator or sustained oscillator that radiation of energy into space may be slight, while in the case of strongly damped oscillations the radiation may be relatively greater; or, to put it another way, when radiation is efficient and great, the oscillations are relatively strongly damped.

In wireless telegraphy, particularly in the spark systems, good radiation is desirable, as also is persistency of the oscillations, so that we have opposed conditions to be met. Persistent oscillations make it easier for "tuning" the distant receiving apparatus, while good radiation means that the energy can penetrate to a greater distance.

Coming now to something more concrete, Fig. 3 represents the Hertz oscillator or transmitter.

Heinrich Hertz was the first to profoundly investigate the subject of high-frequency electric waves or oscillations. In 1888, or thereabout, as professor at the

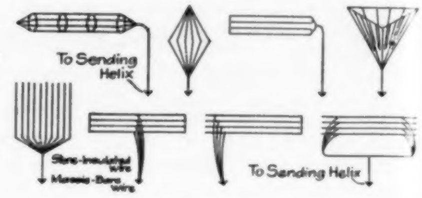


Fig. 6.

University of Bonn, in Germany, he constructed such an oscillator. It consists of two conducting plates, here shown rectangular, each connected to a ball or other spark gap terminal, the balls being separated a short distance to form the spark gap. The secondary winding of an ordinary induction or Ruhmkorff coil has its terminals connected to the spark gap terminals, while in the primary winding of the induction coil is included a battery or other source of energy, suitable interrupter, and a switch or key. The secondary of the coil delivers high-potential current, thus charging one of the capacity areas positively and the other negatively. When their potential rises sufficiently high, a spark leaps across the spark gap, forming an instantaneous circuit closer or bridge over which the electric charge oscillates or vibrates at an extremely high rate. By opening and closing the switch or key the sparking is stopped or started.

His receiver is shown in the lower portion of the figure. It is known as a resonator and consists of a loop of wire having its ends separated by a micrometer spark gap. He chose the product of the capacity and inductance of the loop to conform suitably with the product of the capacity and inductance of the separated plates and their connections in the oscillator, and upon the passage of a spark at the spark gap of the oscillator there was a passage of a minute spark at the micrometer gap of the receiver or resonator.

This was then a complete wireless telegraph apparatus, though in the form shown was not suitable for very long distance work.

Because of the form of the oscillator, having large

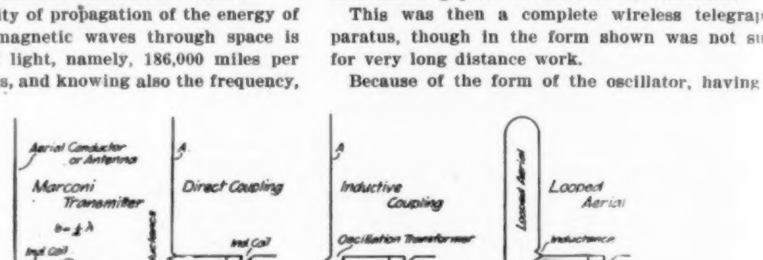


Fig. 5.

separated areas connected by a slender conductor, it has been termed the "dumbbell" oscillator.

So to speak, Hertz set his electric pendulum, the oscillator, into vibration, and his loop or resonator being in electric sympathy with it, tuned to the frequency of his pendulum, his receiver responded efficiently to the frequency of the transmitter and caused the spark at the micrometer gap.

For every impulse of high-potential current from the secondary of the induction coil there was a spark at the gap of the oscillator or transmitter, and for each of those sparks there was generated a "train" or "group" of high-frequency oscillations or waves.

This may be illustrated by Fig. 4.

To represent a "dot" in wireless telegraphy a few wave trains or wave groups succeed each other, while for a "dash" a greater number of wave trains or groups succeed each other, this being determined by the length of time the key or switch in the primary of the induction coil is held closed.

Coming now to the original Marconi transmitter, illustrated in Fig. 5, we have in the left-hand view an aerial conductor on antenna, as it is indifferently called, consisting of a wire or conductor extending upward above the earth's surface and having its lower

* Proceedings of the Engineers' Club.

end connected to a spark gap terminal, the other spark gap terminal connected to earth, the secondary of an induction coil connected to the spark gap terminals and the primary including the source of energy, key, and interrupter. You will at once see that this is precisely the Hertz oscillator of Fig. 3, the aerial conductor or antenna of Fig. 5 representing one of the capacity areas of Hertz's oscillator, while the earth is the other. Here the oscillations are produced in the aerial conductor or antenna and are radiated from it in all directions, as light from a candle. It has been found that where the oscillations are generated in the aerial conductor itself the length of the aerial conductor is equal to one-fourth the length of the wave

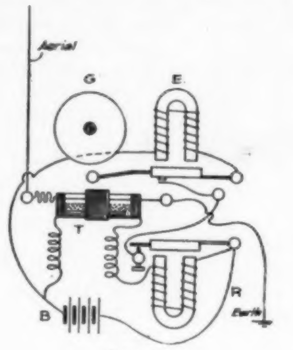


Fig. 7.

generated in it. Thus, if the aerial conductor is 150 feet long, the length of the wave generated in it and radiated from it is 600 feet. Such an aerial conductor, having relatively small inductance, is a good radiator, the oscillations being capable of dying out quite rapidly owing to the radiation of energy into the surrounding medium.

In the next to the right-hand view is shown an inductive coupling, the high-frequency oscillations being produced in a circuit including the spark gap *S G*, the condenser, and the primary of an oscillation transformer, the secondary of the oscillation transformer being connected in series between the aerial conductor and the earth. This makes a very good transmitter; the frequency of the radiated energy may be very closely determined and controlled and the oscillations are not generated or produced in the aerial conductor, but are forced thereon through the medium of the oscillation transformer. So that here the antenna does not entirely determine the frequency or wave length of the radiated energy. However, if the oscillation circuit, including the condenser, spark gap, and primary oscillation transformer, has a natural frequency which is relatively low, and the length of the antenna is far below one-quarter of the wave length corresponding to the oscillations in the condenser circuit, the antenna will not be radiating to the best advantage. This condition of affairs is often met in the matters of contract with the government where, with a given output of the current generator at the transmitter, a great range in wave lengths radiated is required. To store in the condenser the full output of the generating apparatus the condenser must be relatively large. Yet when the condenser is of relatively great capacity it reduces the frequency and, therefore, increases the wave length of the oscillations in the condenser circuit. And this, in turn, means that a given aerial conductor will be too short to efficiently radiate the low-frequency energy, while at the higher

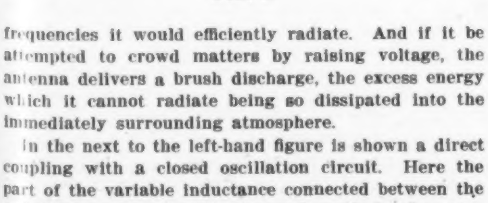


Fig. 8.

frequencies it would efficiently radiate. And if it be attempted to crowd matters by raising voltage, the antenna delivers a brush discharge, the excess energy which it cannot radiate being so dissipated into the immediately surrounding atmosphere.

In the next to the left-hand figure is shown a direct coupling with a closed oscillation circuit. Here the part of the variable inductance connected between the radiating or aerial conductor and earth is also common to the closed oscillation circuit, including the spark gap *S G* and the condenser. This makes an excellent transmitter, and by adjusting the amounts of inductance in the aerial and in the condenser circuit the aerial path may be brought into tune or resonance with the closed oscillation circuit.

In the right-hand view is shown a looped aerial conductor which is not insulated at the top, but has its top connected to earth. The connection between the condenser or oscillation circuit and the aerial conductor is a direct coupling, as in the next to the left-hand view.

These views of Fig. 5 represent elementally some of the better known and more useful transmitters as used to-day, though the early Marconi transmitter is seldom, if ever, used, except perhaps by amateurs or for very short transmissions.

In Fig. 6 are shown elementally different constructions of aerial conductors without regard to the form or type of oscillation producer used in connection therewith.

In the upper left-hand corner is shown a wire cage located at the top of the aerial conductor, either horizontally or in any other position, which gives added capacity at the top of the conductor. The next below shows also a multiple arrangement of wires at the top. The one next shows a plurality of wires extending vertically and having a common connection at the bottom to the sending apparatus. The one in the lower right-hand corner shows a plurality of horizontally disposed wires at the top, connected in parallel with each other and connected together at the bottom to the sending apparatus. There is shown also a spread-out antenna of a plurality of wires in diamond shape; and also an inverted three-sided pyramid arrangement. Next below is a plurality of multiple horizontal wires connected together from their centers to sending apparatus. And there is shown a plurality of horizontal wires at the top having several separated connections coming to a common connection downward to the sending apparatus.

While Fig. 6 illustrates numerous forms of spread-out aerials or antennæ, it has been found good practice also to have the aerial conductor composed of a plurality of wires which are closely bunched instead of being spread out. With a spread-out arrangement, if the spread is any considerable fraction of the wave length, each conductor sends out its wave, and there

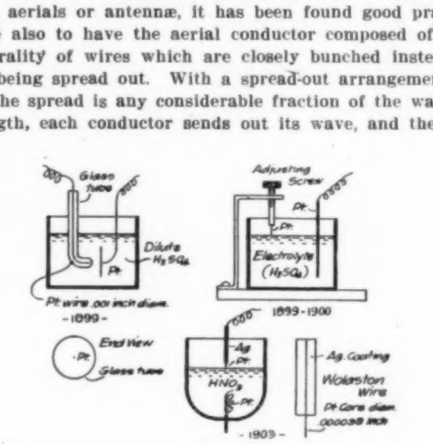


Fig. 9.

results a combination of dephased waves in space, which is a disadvantage in most cases to the receiving apparatus.

Coming now to receiving apparatus, probably the first practical wireless telegraph receiver was devised by Popoff, of the Russian navy, who in 1895 devised the apparatus shown in Fig. 7. This apparatus was for use in recording and predicting lightning storms, some recorded being at such distance that at the location of the recording apparatus it was not otherwise known that a lightning storm existed. The flash of lightning produced became a natural spark gap or natural producer of oscillations, and these oscillations were picked up on an aerial wire whose lower terminal was connected to one terminal of the filings tube or coherer *T*, the other terminal being connected to earth. The coherer or filings tube *T* comprised separated terminals within a glass tube, between and in contact with which was placed a mass of iron or other metal filings. Such a device, as found in 1892 by Branly, was sensitive to electric waves or high-frequency oscillations. The device normally has a very high resistance, but upon high-frequency oscillations traversing the device the filings drop enormously in resistance (the resistance reduction is used to produce the signal) and remain in the condition of low resistance until mechanically shocked, when they again resume the high-resistance state. The action has been explained as one of cohesion, and, therefore, the device has been termed a "coherer." And though detectors or wave-responsive devices coming later in the art did not comprise filings or anything like them, the term "coherer" became for a long period a general one to denote all types of wireless detectors. Popoff connected in series with the filings tube the battery *B* and the relay *R*, the relay controlling also a local circuit including the winding of an electric bell magnet *E*, the hammer being used to strike the tube, to automatically restore the tube to sensitive conditions. Popoff's arrangement was, in fact, a perfectly practical wireless telegraph receiver.

Later, Marconi used almost indentically this arrangement as his receiving apparatus in connection with the transmitting apparatus shown to the left in Fig. 5.

Coming now to later forms of the receiving apparatus, and such as may be taken as fairly representative of types, without going into great detail, Fig. 8 shows in the left-hand figure a non-tuned receiver having an open aerial conductor, between which and earth is connected a detector comprising carbon filaments resting on steel knife edges, and in a local circuit is included a telephone and a battery. At each spark at the distant transmitting apparatus a train of waves is radiated into space, and these waves impinge upon the aerial conductor, setting up therein minute high-frequency currents or oscillations which surge up and down in the conductor through the detector or oscillation-sensitive device, causing it to change its condition suddenly, to thereby cause increased or decreased current through the telephone, producing therein a click, such click corresponding

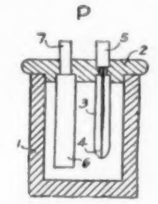


Fig. 10.

with the spark at the distant station. Several clicks coming close together indicate a dot, and a longer series of clicks indicates a dash. This has been called a non-tuned receiver, though it may be roughly tuned to the transmitting apparatus if the dimensions and disposition of the aerial conductor are similar to those of the aerial conductor of the transmitting apparatus.

In the middle sketch is shown a tuned receiver having an aerial conductor, between which and earth are connected the variable inductance and variable condenser. In shunt to the condenser is connected the detector or sensitive device, and in shunt to it is connected a telephone receiver and battery. To get the receiving apparatus into tune the condenser or inductance, or both, is or are suitably varied.

In the right-hand sketch is shown a looped aerial conductor with tuning apparatus, the latter comprising an adjustable inductance and an adjustable condenser.

An important element of each wireless telegraph set is the detector or sensitive device at the receiving station. A good detector, one which is very sensitive yet rugged, and not likely to get out of order, is an important factor in satisfactory wireless telegraphy and telephony. But even with the best of detectors, if the transmitting apparatus is not of the best form or type, or if the receiving circuits independent of the detector are not of the best form or type, successful communication cannot be had.

In Fig. 9 are illustrated several forms of detectors. It will be recalled that the filings coherer had to be tapped to restore it to sensitiveness ready to respond to the next train of received waves or oscillations. It was not, therefore, a self-restoring detector or receiver. The receivers or detectors of Fig. 10 are all self-restoring; that is, immediately after response has been made to a received wave train, it restores itself, or automatically returns to sensitive condition ready to respond to the next train of arriving waves. All the detectors shown in this figure are of the liquid type; that is, they comprise two terminals bridged in one form on another by liquid.

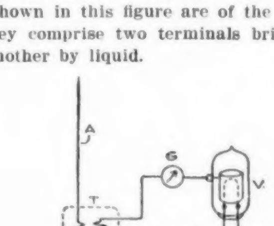


Fig. 11.

In the upper left-hand corner is shown the Pupin detector of 1899, due to Prof. Pupin of Columbia University, who used it to detect Hertzian oscillations, just such oscillations as are used in wireless telegraphy. The action was, as he believed, a rectification of the Hertz waves, more or less complete. The high-frequency alternating currents or Hertzian waves or oscillations were believed to act upon the cell with its adjuncts in such fashion that the oscillations were more or less rectified. But, whatever the action, the result was that an indicating instrument gave a decided indication at each spark of the transmitter, or what is the same thing, for each train of waves generated and received. This detector consists of a mass of dilute sulphuric acid in which dips a terminal of platinum, wire or plate. The other terminal is a platinum wire, 1 mil. (0.001 inch) in diameter, sealed

in a glass tube, the platinum wire being polished or ground off flush with the end of the glass so that only the cross-sectional area of the end of the glass is exposed to the solution. This small area is separated in the sulphuric acid from the other and larger platinum terminal. This is, indeed, a sensitive detector, and the author has himself successfully employed it in Philadelphia at the wireless telegraph station on the Bellevue-Stratford Hotel; and without any effort at tuning has received distinct and loud messages from New York and Washington. And with crude tuning apparatus, which is necessary with even the best of detectors, it was possible to pick up messages from very much greater distances. Indeed, so far as the author knows, the Pupin detector is about as good, all matters considered, as exists today.

The Pupin detector, exactly as shown in the figure, has been used with marked success in the United States navy.

At the upper right-hand corner of Fig. 9 is shown a very similar detector due to Capt. Ferrié of the French army. In 1899 and 1900 he successfully used this detector, platinum and platinum in dilute sulphuric acid, in transmitting messages between the different army stations or forts around Paris, as Capt. Ferrié himself told me. Like the previous detector, it is self-restoring, and it is, indeed, the same in principle.

Later, in this country, there was evolved the Wollaston wire form, using one large platinum terminal in nitric acid, and as the other terminal the platinum core of a Wollaston wire projecting into the acid. The platinum core is extremely fine, being only about 0.00004 inch in diameter—a microscopic wire. This produces a very sensitive detector, but is not as rugged as the Pupin form, where the wire is inclosed in glass and is not so easily destroyed. The Pupin arrangement is "fool proof," while the Wollaston wire type is much more delicate and probably more sensitive.

In Fig. 10 is shown still another form of self-restoring detector, consisting of the Pupin glass tube, 3, with the small platinum wire, 4, sealed in and ground off flush with the glass. This dips into dilute sulphuric acid or other cell excitant contained in the jar or vessel, 1, the other element being a plate or bar, 6, of zinc or other metal or conductor other than platinum. This device having dissimilar metals thus constitutes a primary cell, and it is known as the primary cell detector. It is very sensitive and, like the Pupin device, is "fool proof." The telephone is connected directly to the terminals 5 and 7; no local battery is employed.

In Fig. 11 is shown a curious type of detector accredited to Prof. Fleming, of England. It is called a "valve tube," and consists of an exhausted bulb *V* similar to an incandescent lamp bulb, in which is a carbon or other filament, shown in dotted lines. Surrounding this is a metallic cylinder, as of platinum. In circuit with the carbon filament is a source of energy *B* to keep it incandescent. The oscillations delivered from the secondary of the oscillation transformer *T* pass through the indicating instrument *G* to the plate in the vicinity of the heated carbon filament; the heated carbon filament forms the other terminal of the detector. This device is said to be a rectifier, causing the high-frequency current waves or oscillations to be rectified to give an indication in the instrument *G*, which may be a telephone.

A detector resembling the Fleming detector is called the "Audion." Both of these detectors are self-restoring. A carbon filament within an evacuated bulb is kept hot or at incandescence by the source of energy or a battery. The carbon filament forms one terminal of the detector, being connected to earth, while the other terminal within the bulb is of platinum or other suitable material, and connects with the receiving circuit. In the local circuit is a battery and relay, telephone or other instrument. Rectification probably occurs here also. But it is immaterial what the process may be in any detector; the fact is always that the received oscillations produce a change in or by the detector, which change is noted in the telephone and read by the operator. Whether the action of a detector be rectification, resistance change, depolarization, or what not, is a matter of extreme indifference from the commercial and practical standpoint, inasmuch as whichever of these or other processes may occur, the result is the same in that the operator hears a click in his telephone for each spark at the transmitting station.

(To be continued.)

AEROPLANES IN PARIS.—II.*

THE FRENCH SALON.

Concluded from Supplement No. 1820, page 335.

There is obviously considerable hope for the future of aviation when so much intelligent criticism is directed against the machines exhibited at the Paris show. A year ago they were regarded with wonder and admiration, and while this was still the dominant feeling among the huge crowds who flocked to the Grand Palais, there was a general impression among those who are interested more or less in aviation that the construction of the machines fell short of what it should be. There is, indeed, too much of the makeshift about the construction of many of the aeroplanes. While anything may do for experimental appliances, it is expected that a machine which is presented as a settled type will satisfy the mechanical mind; but this is what it fails to do. Wood, wire, and fabric constitute materials which, in many cases, are put together in a haphazard way. The controlling gear of one aeroplane has been aptly described as a "broomstick with string all around it." As an illustration of the want of mechanical knowledge, or perhaps merely thoughtlessness, in the building of aeroplanes, we will take the stays of steel strip which have replaced piano wire on many machines for bracing the under part of monoplanes to the body. These stays work under tension, and have to bear the whole weight and load, as well as the sudden additional strains put upon them when maneuvering. Piano wire may rust and snap at the joints. The steel strip used as a substitute obviously provides an ample margin of safety, but the ends are riveted between a strip bent round a pin held in a lug by bolts. At the point where it is held by the pin, the strip forming the joint, and having a thickness of about 20 wire gage, is narrowed to 4 millimeters. This bears the whole load. On the other hand, there are some machines that are well made and of pleasing design, and the appearance of lightness and finish given to certain of them is distinctly attractive, but in a general way it must be admitted that in the designing of aeroplanes due consideration has not been given to securing the maximum strength.

The general impression of aeroplane progress may be summed up in the suggestion which has been put forward by the Marquis de Dion for a prize to be awarded to the airman who, during 1911, is able to show the greatest difference between his fastest and slowest speeds over a given distance. There is apparently not a machine in existence that will fly slowly. The greatest difference between fastest and slowest speeds at present is not more than 20 per cent. During the year progress has been solely in the direction of increasing speeds, because this is indispensable for the present types of aeroplanes; but a machine that will fly slowly with safety must necessarily represent a considerable advance upon anything done up to the present time. A slow-flying machine must be comparatively independent of ordinary atmospheric perturbations. The proposed competition has been suggested by the idea which is entertained by every thinking man that research work should be diverted from the present line of aeroplane development. Existing types of machines will, of course, be greatly improved, and may satisfactorily fulfill certain conditions of aerial flight; but it is not considered likely that these apparatus will represent a practical class of flying machine. The question therefore arises whether the aeroplane will be able to free itself from the thraldom of speed without relinquishing the propeller, or whether it will have to adopt some other method of propulsion, such as the comparatively slow displacement of large volumes of air. The idea of building machines with flapping wings has always been regarded with more or less contemptuous disapproval, though for what reason it is difficult to say; but there is no doubt that increasing attention is being given in France to this possible solution of the problem. At the Paris show demonstrations were made with a model similar in construction to a large model which has been flying with remarkable success in the open air, but on account of its size this model could not be shown in flight within the restricted precincts of the hall. The behavior of the smaller model, however, appeared fully to justify the claims of the inventor concerning the capabilities of the larger machine. This has a length of about 5 feet, and is, in plan, a copy of the body, tail, and wings of a bird. Each wing is practically a right angle triangle, with the base and perpendicular forming a rigid member, and over this is stretched a flexible fabric. The base is hinged to the body, and the end of the wire constituting the base is bent at right angles to form a level under the horizontal plane for actuating the wing. The lever is connected by a rod with a double horizontal crank, upon which is mounted a pinion. This meshes in a pinion keyed on the motor shaft, which, in the case of the model, is rotated by the twisting of thick rubber. The model is allowed to start from the hand without impulsion, and flies in a straight line so long as the motive power lasts, and then alights gently on the ground. The wings being quite flat, there would, of course, be no advance if they were rigid, but with each upward and downward beat the fabric bends, and thus imparts a waving motion through the air. We do not go so far as to say that this flapping model performs better than models of fixed planes worked by propellers, but it certainly seems to possess greater stability, as well as an easier gliding to earth, while it is also capable of traveling more slowly. Tests with small models may be regarded as of doubtful value, but if comparative trials could be made with large-size models of the fixed plane and moving plane types, some interesting deductions might be drawn therefrom, which would guide makers in the designing of large-size machines.

So long as the present system of fixed planes and propeller is adhered to a somewhat exaggerated importance has to be attached to the engine. In order to gain speed more powerful and lighter engines are required. This raises a problem of specific engine weight which may eventually find a satisfactory solution, but there are obviously mechanical limitations which cannot be exceeded. Every motor builder is induced, by the high prices paid for suitable aviation engines, to produce designs in which weight is cut as finely as possible. These may be divided into four categories—rotary engines, engines with vertical or V-placed cylinders, engines with the cylinders arranged fan fashion, and horizontal engines. The rotary engine undoubtedly enjoys the greatest favor, and this favor is centered upon the Gnome. Its success has naturally been followed by the introduction of other engines, either with revolving cylinders like the Gnome or of the true rotary type. At the show there were no fewer than nine of these engines, of which two, the Beck and the Breton, were exhibited last year. In the Beck the cylinders are constituted by an annular chamber in which the pistons travel through the arc of a circle, and are connected with the crank shaft by levers. If the crank shaft is fixed, the annular chamber is driven round the axis. The Rossel-Peugeot is an improvement of the rotary engine built by Peugeot some years ago. It has seven cylinders, and its special feature is the method of distribution by means of a shuttle traveling in a double cam-shaped groove crossing the path in such a way as to insure contacts at the correct moments. It is claimed that this system offers greater security and certainty than the rollers and cams usually employed on rotary engines. In the Canda engine there are ten cylinders, with the axes at a tangent to the center of rotation. The pistons are fixed so that when the explosion takes place it is the cylinder which must move and this it can only do in a circular direction. This is the principle of most of the so-called rotary engines. The chief reason for the popularity of this type of motor is that it offers the highest air-cooling efficiency, but it also possesses certain drawbacks such as the projection of oil into the explosion chambers which it is not easy to obviate, while the power it develops on an aeroplane is considerably less than on the bench. Being an essentially high-speed engine, it has to be throttled to the maximum number of revolutions allowed for the propeller, and the power developed during flight is not more than two-thirds of what the engine will develop on the bench. It has also been argued that the rotary engine offers a resistance that must be considerable with the high speeds at which aeroplanes travel, and if the rapidly rotating cylinders may be regarded as a solid disk it is obvious that the power absorbed in overcoming this resistance at great speeds must be very high. Probably it is for this reason that in the latest Blériot machines the engines are placed inside the body, which is curved forward to diminish resistance.

If the Gnome engine is so largely adopted on account of its convenience, a good deal of attention is nevertheless being directed to the engine with vertical or V-placed cylinders. It is still an open question

* The Engineer.

whether the aviation motor of the future will be designed on new principles or whether the desired result will be attained by taking existing engines and cutting down weight and using high compressions and large valve areas. This type certainly suggests reliability which is often wanting in the newer engines, and although the weight is added to by a water jacket and radiator, a properly constructed engine nevertheless constantly develops its full power, which is not the case with certain special types of aviation motors that rapidly fall off in power after running a few minutes through the expansion of the cylinders. Still, by the use of aluminium alloys for pistons and certain other parts, and of high-resistance steels, the weight per horse-power has been reduced to a point which renders these engines quite suitable for aeroplane work. One objection to vertical engines is that on monoplanes the center of gravity is unduly high, and for this reason the makers of the Gregoire-Gyp engine have turned their motor upside down, which has necessitated special arrangements for lubricating the pistons from a small oil tank at the top of the crank case. Here, again, it seems difficult to prevent oil from getting into the combustion space. This question of center of gravity is also responsible for the increased headway made by the horizontal engine with opposed cylinders, which at one time enjoyed a good deal of vogue. This type, however, very soon lost favor on account of the excessive weight-cutting rendering its working somewhat precarious, but the fact that several of these engines were shown, including one by the makers of the E. N. V. engines, proves that the horizontal engine has not lost its attraction. What has been said about weight-cutting may apply to vertical and other engines, for when buyers who impose conditions of weight see that they are carrying the demand for lightness to a dangerous extent they will themselves ask for more material to be put into the construction of engines in order to increase their strength and solidity. That lightness is not always incompatible with strength is observable in the Oerlikon horizontal engine, where the thin steel cylinders are liners in an aluminium alloy casting forming the engine bed and crank case. Another means of securing lightness in engine construction is the arranging of the cylinders fan fashion, usually to the number of five or seven, so as to reduce the length of the crank shaft and case. The cylinders are usually ribbed, but while the Anzani has been extensively adopted, and the R.E.P. is a characteristic example of this type, it cannot be said that the fan-shaped air-cooled engine has justified its former vogue. Obviously a reliable air-cooled engine would overcome many difficulties, but as the cylinders often dilate through the heat caused by the employment of high compressions these types of engines do not always maintain a continuous high efficiency. To sum up, a vast amount of research work is being carried out in aviation motors, but while there are several more or less satisfactory engines on the market, there is not one that, so far, has entirely fulfilled the requirements of the aeroplane makers.

The object of aeroplane builders has been to reduce the design of their machines to the greatest possible simplicity, and this has been done in most cases by fixing the propeller direct on the engine shaft. The recent series of fatal accidents, however, has raised the question whether this method of fixing the propeller does not constitute an element of danger. The majority of aeroplane makers are still opposed to the clutch, but several have adopted it, and on most of the new machines under construction a clutch is interposed between the engine and propeller. The difficulty in the past has been the absence of a satisfactory small and light clutch which would transmit the high powers used on aeroplanes. This apparatus must not only be very light, but it must fulfill the apparently conflicting conditions of taking up the load very gradually, and then be locked for a positive drive. In the Hele-Shaw clutch, shown at the Paris Exhibition, this is accomplished by a new system of mechanical control whereby very high pressures are put upon the corrugated disks through the medium of a system of levers acting between ball thrust races. These races are placed at each end of two concentric sleeves, and the fixed sleeve constitutes the fulcrum of a lever for advancing the other sleeve, and with it the ball race and presser plate acting on the disks. This lever is actuated by a second lever, provided with a spring, which limits the pressure on the disks to well within the normal load of the thrust ball races. Owing to the enormous leverage obtained by this combination, an effort of 20 pounds is sufficient to put a pressure of 660 pounds on the disks. As, moreover, a further leverage is obtained by connecting up the lever with a pedal, the final effort required is extremely small. The pressure is required gradually to take up the load, and when the full pressure is on the disks the wedging effect is so considerable as to render the drive practically positive. There is no axial thrust either when clutching or declutching. The weight of the 100-horse-power clutch for aeroplanes is 23 pounds. On the larger clutches for dirigible balloons, such as are fitted to the "Ville de Lucerne," "Ville de Bruxelles," and others, the levers are replaced by an irreversible screw acting between ball thrust races. The weight of these clutches for transmitting 250 horse-power is 60 pounds.

HOW TO REPAIR AND CLEAN TYPEWRITERS.

A SECRET PROCESS REVEALED.

As every user of a typewriter knows, the platen or roll is the part of the machine that wears out first. The constant hammering of the type against the surface of the platen soon makes indentations in it, which in a short time amount to such a degree of roughness that it is impossible to produce good, clean work.

A compound has recently been discovered that will restore the platen to its original smooth condition no matter how badly it is worn or how long it has been in use.

The formula and the method of using the compound are as follows: The ideal material for use in repairing platens would be hard rubber, but in the process of vulcanizing, the rubber becomes insoluble to a great degree in the solvents generally used for making rubber solutions. As a substitute for hard rubber, celluloid is recommended. The hard variety should be used, which is sold under the name of imitation ivory. This is soluble in acetone, amyl acetate, and various other solvents. One of the best solvents is a mixture of eight ounces of acetone and one ounce of amyl acetate.

In the absence of anything else in the way of celluloid, any ordinary article made of this substance, as a comb, may be used. There is a variety of celluloid used in the manufacture of combs which is quite satisfactory for this purpose. The color also is good where this variety can be obtained.

In using celluloid on platens it is advisable to use something with it that will give it hardness, such as finely powdered silica, infusorial earth, emery, or other similar substances. About one ounce of powdered emery to each eight ounces of compound is a fair proportion. Powdered soapstone also works well for the purpose.

The celluloid solution should be made as thick as a very heavy syrup or molasses. In fact as thick as may be spread with a brush. The heavier it is when used, the sooner it will dry. If a light colored celluloid is used, it is advisable to add some coloring matter, which may be lampblack or preferably gas or carbon black. Just enough should be used to give the desired grayish color. Remove the platen from the machine. The work may be done with the platen in the machine, but great care must be taken to protect the working parts from the dust formed when smoothing up. It also takes less time to do the work when the platen is removed.

Wash the platen with gasoline to remove all grease and dirt, and rub it with a piece of fine emery paper, to give it a new clean, surface. With a brush, paint the mixture carefully over the platen, giving it a good thick coat.

Lay the platen aside for six hours or longer for the composition to harden. Then, with a piece of fine emery cloth, smooth it down, taking care not to cut quite to the original surface of the platen. This is the delicate part of the work; and upon the care used in doing it depends the quality of the job.

Acetone and amyl acetate can be obtained at any drug store. It usually requires from two to five hours for the celluloid to dissolve. Breaking it up into small pieces hastens solution. The solution should be prepared in a wide-mouthed bottle that can be securely corked. It should be shaken often during the process as this will prevent the celluloid from forming in lumps. The bottle should be kept tightly corked and away from fire, for it is highly inflammable. Should the mixture become too thick, thin it with a little more of the solvent; if it is not thick enough, add more celluloid.

A cheap and simple cleaning compound for typewriters is composed of the following ingredients:

Paraffin oil	1 pint
Benzol	5 ounces
Cresol	1 drachm
Kerosene	4 ounces
Mix thoroughly.	

This compound was for years a secret confined to one or two of the large companies that rebuild typewriters. The machine is immersed in the compound which quickly and thoroughly dissolves and removes all dirt, gum, grease, etc. It does not injure the enamel, but on the contrary improves its appearance, making it as bright as when new. In making up any desired quantity of this compound retain the proportions given in the formula, except that should a quicker drying mixture be desired the quantity of paraffin oil may be reduced and the kerosene increased. In all cases the lightest grade of paraffin oil should be used and not the heavier lubricating oils. If white paraffin oil is used, a water white fluid is produced; if dark paraffin oil is employed, the liquid has a light amber color. Oil of citronelli or oil of sassafras may be substituted for the cresol, which has no action whatever and is used simply to disguise the composition of the compound.

To use the compound, fill a tub of sufficient size with it. Place the machine in it and allow it to remain in the fluid for half an hour. By lifting it up and down gum and grease will be washed off. Then remove it and dry it with a soft cloth, brushing the parts not accessible with the cloth. About two gallons of the mixture are required in the average case. The compound may be used as long as any of it is left as the dirt settles to the bottom of the tub and the clean portion may be drawn off. It is necessary to keep it covered tightly when it is not in use to prevent evaporation of the benzol. A fair preparation may be made by using one-third the quantity of paraffin oil mentioned in the formula, an equal quantity of kerosene and from one and one-half to two times as much gasoline.

GAS ENGINE TEMPERATURES.

ON The Cyclical Changes of Temperature in a Gas-Engine Cylinder Near the Walls, Prof. E. G. Coker, M.A., D.Sc., before the British Association for the Advancement of Science, said: Experiments carried on in the latter part of 1908, show that the temperature at the inner surface of a small gas-engine is about 240 deg. C. (464 deg. F.), and the cyclical variation is usually less than 10 deg. C. (50 deg. F.). The steady conditions of low temperature at the wall surface are maintained by the jacket water, although the explosion of the gaseous mixture produces very great changes of temperature close to the walls. This variation has not hitherto been measured for a complete cycle owing to the difficulties which occur in measuring the highest temperature of the explosion. In order to obtain the cyclical variation near the walls, a couple was made of an alloy of 10 per cent iridium and platinum, with a pure platinum wire, and this was secured in a metal plug so that it projected ¼ inch into the cylinder. On light loads and weak mixtures the cycle remained unbroken, but near full load the platinum wire melted. Couples made from 10 per cent alloys of iridium and rhodium with platinum were afterward used, having an electromotive force E above 500 deg. C. (932 deg. F.) given by $E = -174 + 7.6075\,T - 0.00167\,T^2$, where T is the temperature Centigrade. The junctions were rolled down to five or six ten-thousandths of an inch thickness and inserted at a depth of ½ inch from the cylinder wall. These couples were able to withstand the highest temperatures near the walls, and they were not melted except during abnormal explosions. Measurements of the cyclical variations showed a variation of E.M.F. lying between 1.56 and 7.83 milli-volts with an average cold junction temperature of 30 deg. C. (86 deg. F.). The temperature variation corresponding to these values ranges between 250 deg. C. (482 deg. F.) and 1,700 deg. C. (3,092 deg. F.). In estimating the highest temperature reached, the upper limit of temperature is indicated by the partial melting of one of the wires when the engine ran above its full normal load, and the lower limit is indicated by the melting of platinum wire. The melting-point of platinum is 1,710 ± 5 deg. C. (3,310 ± 41 deg. F.), and in the absence of definite values of the melting-points of the alloys used, it is assumed that both are below the melting-point of iridium, for which Violle's value is 1,950 deg. C. (3,542 deg. F.). The probable causes of error in the measurements are discussed, and the conclusion is reached that the temperature at the place of measurement has a maximum value between 1,850 deg. and 1,900 deg. C. (3,362 deg. and 3,452 deg. F.).

IN THE HEART OF AFRICA.—I.*

THE EXPEDITION OF THE AMERICAN MUSEUM OF NATURAL HISTORY.

BY MARY CYNTHIA DICKERSON

Two members of the Museum staff, Messrs. Herbert Lang and James Chapin, are in the Upper Congo region, that great steaming land of equatorial Africa shrouded in jungle. They have slowly sailed up the Congo River, one of the three largest rivers of the world, and least well known; they have traveled on foot through dense tropical forests, proceeding for hours through swamps until, as described by one of them, they were dripping and picturesque like the mighty jungle trees with innumerable hangings and decorations. They have seen strange places and stranger primitive peoples, of whom it is time that the world obtain complete scientific record in view of the rapid advance that civilization must make in the Congo in the immediate future. The photographs that they have sent tell a small part of the story of their progress into this heart of Africa, giving, however, a realization of the inadequacy of cold gray pictures to make vivid a tropical country, the splendid color, the sounds, the life—and the heat. It was in regard to the last that Mr. Lang wrote the following advice to a friend: "While looking at the pictures get into a Turkish bath. You will appreciate the country better."

* Reprinted from the American Museum Journal.

CONGO HORNED VIPER.

The Congo is probably one of the most promising unexplored fields for zoological work in the world. There has been every reason to prevent investigation of the region previously. Civilization has ignored the west coast of Africa. The world knows the north, east and south coasts, but mystery has been attached to the whole six thousand miles of the coast on the west where surf continually thunders.

The Congo, inland, is cut off from communication with the north by the desert of Sahara, from the east and the valley of the Nile by high mountain ranges, from the south by trackless jungle and misty swamp. It lies in the heat of the equator, inaccessible and inhospitable, a country of nearly one million square miles, larger than Europe leaving out Spain and Russia. It has been given over to fever and to sleeping sickness, to raiding Arabs, and to various negro tribes victims of slavery, and more or less cannibalistic in habit. It has neither sent out invitation nor given cordial greeting to the white man, who up to 1871 had

SHORES OF THE LOWER CONGO PHOTOGRAPHED FROM THE STEAMSHIP "LEOPOLDVILLE."

SHORE OF THE LOWER CONGO PHOTOGRAPHED FROM THE STEAMSHIP "LEOPOLDVILLE."

IN THE HEART OF AFRICA.

not been more than one hundred and fifty miles from the coast. At that time no one knew whether the head waters of the Congo belonged to the Niger or to the Congo. Not till four centuries after the discovery of the river was it charted, that is, by Stanley in 1877.

Latterly, conditions have wholly changed. There is now a lure for all nations in ivory, gold and rubber. The Arabs have been driven away and the slave trade abolished. Where formerly there was no way of transferring objects from the coast except on the heads of negroes, now ocean steamers discharge cargoes at a railway pier one hundred miles up the river, a railroad continues to Leopoldville, 320 miles from the coast, connecting there with steamers for points still farther inland.

The Congo River between the coast, or more properly between Boma, one hundred miles from the coast, and Leopoldville, is a cataract region, a stretch of two hundred miles through which there is a rise of land from 700 feet above sea level to 2,500 feet; or considering it in the other direction, down the river instead of up, there is a drop of 1,800 feet through which the vast volume of water passes in a series of plunges from Leopoldville to Boma. It is this impassable cataract region that kept secret for so long the great highway of the Congo. Pass these two hundred miles and the Upper Congo stretches on through 1,100 miles of smooth river, making its tributaries one of the greatest systems of natural canals on the globe.

For many years, the late President Jesup held the hope that an expedition from the American Museum might be sent to the Congo. Even early in 1907, preliminary plans had been discussed with the Hon. Mr. Liebrechts, Secretary General of the Department of the Interior of the Congo, the negotiations being carried on through the Hon. James Gustavus Whiteley of Baltimore, Consulat Général de l'Etat du Congo, and the Hon. Pierre Mali of New York, Belgian Consul and an intimate personal friend of President Jesup. In May, 1907, the plans were so far advanced that Hermon Carey Bumpus, Director of the Museum, went to Brussels to confer with the Belgian officials. As a result of these negotiations the patronage of King Leopold was obtained for the project, a patronage which he evidenced at once by presenting large collections of ethnological material, a nucleus for the Museum's African halls. With Director Bumpus, the hope for an expedition to the Congo became one of the most cherished among his many plans for the rapid advancement of the institution along lines co-ordinate with the world's progress. His interest, with that of Mr. Whiteley, accrued also by that of Mr. John B. Trevor of the Executive Committee of the Board of Trustees, finally crystallized in a Congo Expedition Committee appointed late in the fall of 1908 by Henry Fairfield Osborn, president of the Board of Trustees, and consisting of these three men, Mr. Trevor acting as chairman, and of Messrs. Robert W. Goelet, Herbert L. Bridgman and Frank M. Chapman as added associates. The organization of this committee gave definite form and impetus to the negotiations which finally brought about the sanction of the authorities in Belgium to the Museum's exploration of the Congo, and which so controlled circumstances at home that the project dreamed of became a reality.

The history of the following months, in fact, till May 8th, 1909, when Messrs. Lang and Chapin sailed on the "Zeeland" of the Red Star Line for Antwerp, is a fas-

CONGO ANTEATER OR PANGOLIN.

"WIRELESS" STATION AT STANLEYVILLE.

By an intricate system of beating the tom-tom—a log hollowed out through a narrow slit—news is "telegraphed" at night. The sounds repeated over and over carry six or seven miles.

EMERGING FROM THE FOREST NEAR AVAKUBI.

In Central Africa, more than 8,000 miles from New York. A caravan of more than 200 people was necessary to transport the expedition's equipment from Stanleyville to Avakubi.

SHORE OF THE LOWER CONGO PHOTOGRAPHED FROM THE STEAMSHIP "LEOPOLDVILLE."

IN THE HEART OF AFRICA.

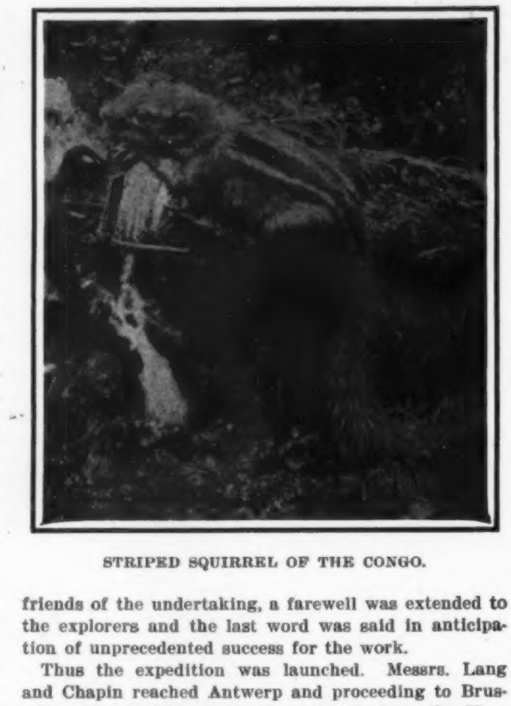
cinating chapter of work preparatory to the launching of a great expedition.

The matter of financing the expedition was taken in hand by a group of the Museum's members and friends, to whom the institution is deeply indebted and to whom the world in the future will be indebted because of the large scientific value of the expedition. They are Messrs. John B. Trevor, Charles Lanier, Cleveland H. Dodge, J. P. Morgan, Jr., William K. Vanderbilt, A. D. Juilliard, Robert W. Goelet and William Rockefeller.

Plans were outlined for the scientific end of the work: to push at once into the central part of Africa so that headquarters might be located eight hundred or more miles from the coast in a region formerly unexplored zoologically; to make the aim of the expedition a zoological survey of the basin of the Congo, collecting heavy game but also directing energies along other lines of investigation, so as to make collections for all departments of the Museum. While awaiting the final arrangements with the Belgian government, co-operation and enthusiasm among those concerned pushed the undertaking to a wonderful success in its preliminary stages, assuring an aim and scope to rank the expedition as perhaps the greatest the Museum ever sent out.

Finally there came a day of good news, April 2nd, 1909, marked by the receipt of letters from His Excellency Baron Moncheur of the Legation de Belgique at Washington and from the Hon. Mr. Whiteley at Baltimore announcing that there had been secured not only the support and necessary good will of the Belgian government but also an appropriation of 6,800 francs ($1,329.23) toward the expense of transportation in the Congo. The compact agreed upon provided that in return the expedition should give to the Tervueren Museum, Belgium, certain suggested zoological specimens lacking there. The co-operation is expressed by the following words quoted from the reply of Director Bumpus to Baron Moncheur: "The American Museum of Natural History will consider it a privilege to be permitted to share the scientific results of this expedition to the Congo with the Museé du Congo in Belgium. We are confident that the combined efforts of the Colonial Administration of the Kingdom of Belgium and the American Museum of Natural History will result in the general promotion of science and thus redound to the benefit of all people."

Practical work could now be pushed rapidly. Passports were obtained from the Secretary of State at Washington, steamship tickets were purchased, permits for freight obtained, money cabled to the Banque du Congo, Belge, Brussels, to be held at the disposal of the expedition. Through the courtesy of Mr. H. L. Bridgman, a member of the Congo Committee, letters of introduction were obtained to persons in Brussels, in particular to His Excellency, the Hon. Mr. Lane Wilson of the United States Embassy; and in each case the new allies proved their personal interest by writing to officials in the Congo. On April 16th, at a dinner given by President Osborn to the Congo Committee and other



STRIPED SQUIRREL OF THE CONGO.

friends of the undertaking, a farewell was extended to the explorers and the last word was said in anticipation of unprecedented success for the work.

Thus the expedition was launched. Messrs. Lang and Chapin reached Antwerp and proceeding to Brussels were cordially received. A letter from the Hon. Mr. Lane Wilson to His Royal Highness Prince Albert de Ligne brought invaluable services in securing concessions for the expedition; all articles for scientific purposes, except rifles, to be duty free; the collecting to extend not only to all ordinary specimens throughout the year, but also to the rare white rhinoceros of the Lado district, the elephant in Ituri, the white gorilla recently found in the Kivu region, and the okapi, that recently discovered interesting relative of the giraffe.

In Brussels and London the equipment was completed, an equipment which throughout was based upon such sound considerations that the expedition is having unusual strength in the field. Special consideration was given to the medicine chest and to the tents. Through the courtesy of the Secretary General, Mr. H. Droogmans, it was most fortunate that the Chief of the Medical Service was met, Dr. Emile Van Campenhout. With ten years experience in the Upper Congo and many years of investigation of Congo diseases, especially of the sleeping sickness, he could advise pre-eminently well. He inspected the expedition's tents and pronounced them ideal for the region, recommending for night the partly closed rather than the all-round open tent used by the British in tropical work—for daytime use, however, recommending the all-round ventilating type.

Finally in the first week of June the start was made for Africa on the steamship "Leopoldville" and after twenty days' sail Boma was reached, one hundred miles from the coast, the capital of the Congo Free State for the past twenty-eight years. Here a warm greeting was received from the Hon. Mr. Handley, the American Consul General.

It was well that the expedition had planned to push immediately inland, because of the extravagant prices as well as the dearth of life in the region of Boma and Matadi, the latter a town built on ledges of rock a few miles above Boma. Mr. Lang writes:

"You should see the relative poverty of the fauna around Boma and Matadi. This of course goes hand in hand with the general monotony of the country, nothing but hills, one as barren as the other, though occasionally the grass, usually four or five feet high, is replaced in the valleys by a few bushes. The scarcity of bird life is most striking as one enters the Congo River from the sea. The stream is seven miles wide at its mouth, with low shore, reeds, sedges, papyrus, mangroves and, in some places, cocoanut palms. Farther up, false Borassus (palms) and Baobabs become more abundant; yet there are few birds except the common kinds, some terns, swallows, and a few vultures."

(To be continued.)

DEW PONDS.

It is said that when Jack and Jill went "up the hill" on their ill-starred water quest, their destination was a dew-pond on a summit of the English Downs. The hydrology of the Down country is as topsy-turvy as the name "down" itself; for a down is an upland, and the downs of the south of England afford their inhabitants a bountiful supply of water even when the intervening vales are parched with drought. Hence one sees here the singular spectacle of cattle being driven to the hilltops to be watered, and carts being sent uphill to procure water for the dwellings in the valleys below.

What is a dew-pond? The word is only to be found in the two newest dictionaries—the New International and the Century Supplement, both published this year—though it has been used locally for at least a hundred years, and perhaps very much longer.

In the first place, dew-ponds are all artificial, though the construction of the oldest of them dates back to a prehistoric era. The art of making them has not been lost, for Messrs. Hubbard, in their "Neolithic Dew-Ponds and Cattleways," tells us that there is still at least one wandering gang of men who will construct for the modern farmer a dew-pond that will contain more water during the heat of summer than during the winter rains.

The artificial ponds on the downs are not all dew-ponds. Many of them are simply storage reservoirs for water received by surface drainage; but the true dew-pond receives its water directly from the air—whether chiefly in the form of rain, mist, or otherwise is a question still unsettled.

An essential feature of the dew-pond is its impervious bottom, enabling it to retain all the water it gathers, except what is lost by evaporation, drunk by cattle, or withdrawn by man. The mode of construction varies in some details. The bottom commonly consists of a layer of puddled chalk or clay, over which is strewn a layer of rubble to prevent perforation by the hoofs of animals. A layer of straw is often added, above or below the chalk or clay. The ponds may measure from 30 to 70 feet across, and the depth of water does not exceed three or four feet.

The theory that these ponds are fed by dew, in the ordinary sense of the word—i. e., by the direct condensation of the invisible moisture of the air—is supported by little more than the popular tradition implied by their name, and even tradition is not unanimous on the subject. Rain of course supplies much of their water, and may supply all of it, as is maintained by Mr. Herbert Gibson in the current number of Symons's Meteorological Magazine, who bases his opinion on observations made by H. P. Slade many years ago.

On the other hand, Mr. Edward A. Martin, who has been making an extensive series of observations in the downland of Sussex, with the aid of a Royal Society government grant, believes that he has found an important source of the water supply in the frequent mists that drift in from the sea. He is the author of several memoirs on this subject, from the latest of which, published in the Geographical Journal of August, 1909, we quote the following:

"In regard to the question as to how far fog or mist goes toward replenishing ponds, it is well to bear in mind that the term 'mist-pond' has been found in use in the neighborhood of Worms Heath, in Surrey, in Kent, and in Wiltshire, as recorded by Messrs. Johnson and Wright. Mr. Johnson also records, in his 'Folk-Memory,' on Mr. T. W. Shore's authority, that the term 'cloud-ponds' is used in some parts of Hampshire. I am also informed that some of the older inhabitants of Hampstead knew certain ponds on the heath by the name of 'fog-ponds.' . . . Every one acquainted with the Sussex downs must be familiar with the sea-fogs which sweep inland from the south. One's clothing quickly becomes covered with a deposit of dew-like beads, and it seems to me that the warmth of pond water will in no way act against the deposition of mist. . . . I am informed that on some of the downs in West Sussex the highest parts are chosen now for pond construction, as being more exposed to the southwest moisture-laden winds. Dew would not be deposited, of course, if the air were in rapid motion, but fog brought in from the sea would remain in spite of the wind, provided the temperature were sufficiently low, the seemingly stationary fog being in reality continued condensation of moisture."

So the name "dew-pond" is a misnomer; but, as Dr. Hugh Robert Mill has recently remarked, it would be a pity if the picturesque word should vanish.

MANILA COPAL.

According to an article in the Philippine Journal of Science written by G. F. Richmond, Manila copal as exported from the Philippine Islands is obtained from a large coniferous tree, *Agathis alba* (Lam.). Some is found in large masses among the roots of the trees, but by far the greater quantity is obtained by "blazing" the trees. It is graded for the market according to cleanness, color, and the size of the lumps. It is used commercially almost exclusively as an ingredient of oleoresin varnishes. Chemically, it consists essentially of free amorphous acids, a volatile hydrocarbon, a neutral saponifiable substance, probably a lactone, and an unsaponifiable resin. The free acids appear to bear no relation to each other, or to the known resin acids of other coniferous resins. Over 80 per cent of the crude resin is soluble in dilute aqueous solutions of the fixed alkalis, and is precipitated as a pale yellow, amorphous resinous solid when the alkaline solution is neutralized. The author has separated three different resin acids. One, which forms about 4 per cent of the original resin, is a white crystalline body melting at 185 deg. to 187 deg. C. It is monobasic, and has the formula, $C_{10}H_{15}O_2$. The second is amorphous, monobasic, and has the formula $C_{22}H_{34}O_4$. The third, which, however, was not obtained pure, corresponded to a monobasic acid of the formula, $C_{22}H_{30}O_4$. The author has investigated the changes which occur when Manila copal is fused in an open receptacle over a free flame. Samples heated to 275 deg. C. and 300 deg. C. melted to homogeneous mobile liquids, losing about 16 per cent by weight. The melted resin differed from the raw resin only in the amount and nature of the unsaponifiable portion, and consequently the resin which enters into varnish manufacture consists essentially of free acids of the same composition as they had when in the original copal. In view of this fact, the author attempted to form varnishes without previously heating the resin in the customary way. It was found that raw or boiled linseed oil, containing the free, mixed fatty acids of linseed oil in the proportions of 10 to 30 per cent, formed homogeneous solutions with raw or fused Manila copal when the latter was added "in the proportion of 10 to 30 gallon varnishes" and heated for a time at a maximum of 200 deg. C. When the turpentine was added before the oil, the boiling point of turpentine, 155 deg. to 165 deg. C., was sufficiently high to effect complete solution with the exception of such foreign matter as was present in the resin. The subsequent addition of turpentine to the oil and resin did not produce any cloudiness. The varnishes thus prepared gave good permanent surfaces when applied to wood. Mr. Richmond concludes, therefore, that the changes which take place during the cooking of varnish are largely changes in the oil rather than in the resin.

THE PLANET SATURN.

A FEW FACTS ABOUT A REMARKABLE BODY.

ILLUSTRATED WITH YERKES OBSERVATORY DRAWINGS.

BY W. F. DENNING, F.R.A.S.

SATURN is now placed very favorably for the observer, though he rises late. However, the planet shows above the horizon nearly four minutes earlier every night, so that he will soon be visible during the evening hours. He rose on July 30th at 10h. 45m., on August 27th at 8:56, and on September 24th at 7:05 P. M.

The rings are opening, and the planet at every successive opposition in recent years has been assuming a more northerly position; so that the outlook for telescopic observers is excellent, for several reasons. At the coming opposition his declination will be about 10 deg. north, and his altitude from the latitude 52 deg. N. will be 48 deg., so that some fine views of this attractive object may be obtained during the ensuing autumn.

Telescopically Saturn is usually better defined than any other planet, and will bear high powers very satisfactorily. Mars and Jupiter may present an unsteady image, and be seen with soft edges and somewhat blurred markings, but Saturn, at the same time, will be viewed to fair advantage. The moderate brightness of the last orb enforces no severe test upon telescopic performance. Upon a really dark sky Mars and Jupiter are very brilliant objects, and especially so near the time of opposition if a pretty large instrument is employed. Neither Mars nor Jupiter is anything like so difficult an orb as Venus to define, and the first two planets, if examined from about an hour before to an hour after sunset or sunrise may often be beautifully seen. The more delicate and

SATURN SHOWS RINGS OPENED TO THEIR FULLEST EXTENT JULY 7TH, 1898.

difficult markings on a bright planet are never outlined so well as when there is daylight or strong twilight to modify the effects of glare.

Perhaps the best two pictures and most entertaining objects in the heavens are the Moon and Saturn. The moon takes a high place from the marvelous extent of her scenery and the distinctness of its outline. Saturn commands attention from his peculiarly novel shape and absolutely unique aspect. As an object calculated to arouse interest in celestial appearances, Saturn stands alone. No telescopic picture in the firmament can furnish a parallel to the luminous rings which encircle the globe of this beautiful orb.

Yet it must be confessed that as regards detail, Mars and Jupiter supply a more extensive field for study. Owing to the great distance of Saturn from the earth, well-defined markings of irregular character are not often to be distinguished. The belts are conspicuous, and occasionally spots have been seen, but they are far from being comparable, either in point of numbers or distinctness, to those which are displayed on Mars and Jupiter.

In 1903 Saturn exhibited remarkable activity, and a variety of dark spots of irregular form were discernible in the planet's North Temperate region. These were seen and followed by a considerable number of observers during the summer and autumn of the year named. For the time this planet aroused a degree of observational enthusiasm altogether beyond precedent.

From a number of observations obtained between June and December, 1908, I deduced the planet's mean rotation period as 10h. 37m. 56.4s., which is very different from a few older determinations. Thus Sir W. Herschel, from a quintuple belt which he observed at the end of the eighteenth century, obtained a period of 10h. 16m. 0.44s., and considered it correct to within two minutes.

In 1876, December 7th, to 1877, January 2nd, Prof. A. Hall and other American astronomers watched a white equatorial spot on Saturn, and fixed the time of rotation as 10h. 14m. 23.8s., with a probable error of only 2.3s.

Evidently the markings are of the same atmospheric character as those on Jupiter, and are influenced by similar proper motions. At any rate, the spots seen in 1903 gave evidence of a larger rotation period, 23 minutes in extent, than the markings discovered by Prof. Hall. The fact is interesting as proving that the globe of Saturn is surrounded by atmospheric currents, varying in their rates and veiling the actual surface formations on the planet. For this reason the precise rotation period of Jupiter as well as that of Saturn cannot be ascertained.

Undoubtedly the values are approximately known, and the axial motion of Jupiter is somewhat swifter than that of Saturn; but the only planet of our system, except the earth, for which we have been able to fix the accurate time of rotation is Mars, with a period of 24h. 37m. 22.66s.

Perhaps more imaginary belts and spots have been announced as existing on Saturn than on any other member of the Solar System. The comparative faintness of the image, and its smallness, have encouraged illusions when instruments of inadequate size have been used, for belts have been glimpsed in profusion, and features of irregular outline, both light and dark, have been abundantly seen at nearly every opposition in late years. These have been for the most part deceptive, for some of the most reliable and experienced observers with large telescopes have failed to detect any irregularities, at the very same time whe little glasses were stated to reveal them with great ease.

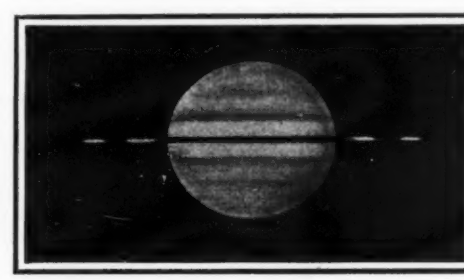
Saturn requires fuller investigation with suitable means. The times of rotation in different latitudes should be determined whenever the necessary markings become apparent. Suitable features have sometimes eluded the study so essential to understand their nature and fix their rate of velocity, owing to the lack of capable observers. Jupiter, it must be admitted, has received ample attention since the great Red Spot became a prominent object in 1878; but Saturn, often viewed for his splendid pictorial effect, is not so frequently scrutinized for delicate features amid his belts and zones.

Since the striking activity which Saturn displayed in 1903, the disk appears to have been normal, and to have given evidence of no similar phenomena of equal extent. But in the case of Jupiter there are recurrent outbreaks of spots and irregular markings, and Saturn, from his size and belted aspect, may well be influenced by the same vagaries.

At every opposition, therefore, the globe of the planet should be critically examined for features which may allow the rate of rotation to be redetermined. The hemisphere which underwent such great disturbances in 1903 is now unfavorably visible, but it is not likely that any region of the planet is quite quiescent.

And not only on the globe, but on the rings of Saturn, there is a prospect of novel appearances being discernible. Terby's white spot was a curious feature, though it does not appear to have been a marking on the rings, since it invariably occupied the same position. We are unacquainted with the actual rotation period of the rings. Laplace, in his "Système du Monde," computed the time of rotation as probably 10h. 29m. 16.8s., and Sir W. Herschel, from certain small luminous points observed in 1789, fixed the period as 10h. 32m. 15.4s.

In 1854 to 1856 Secchi obtained many measures of the rings, and found discordances which led him to conclude that the outer border of these appendages rotated in 14h. 23m. 18s. In 1903 I saw a bright patch on the rings which enabled me to obtain an approximate period of 14h. 32m. for the rotation; but the value is by no means certain, owing to the very brief period over which the observations extended.



SATURN'S RINGS ON EDGE, SHOWING CONDENSATIONS, DECEMBER 12TH, 1907.

The effective study of Saturn can hardly be conducted with any telescope less than a 6-inch refractor or 8-inch reflector, and a 12-inch or 18-inch glass will be found to reveal more than the smaller sizes, especially when the air is very steady and definition at its best. I found a power of 312 very effective in showing the chief markings, and higher magnifiers of 404 and 440 on a 12½-inch. Calver sometimes gave splendid views. Single lenses are best for very high powers; they give more light and better definition than the compound eyepieces.

As Saturn is getting so far north of the equator, it is to be hoped that English observers will secure some new and valuable observations of this magnificent object. Saturn should be studied equally with Mars and Jupiter, though his vast distance laces him somewhat at a disadvantage.

THE GEOLOGY OF CANADA.

OVER the Geological Section of the British Association for the Advancement of Science, Prof. A. P. Coleman presided, and put before his audience the contents of some of the most ancient chapters in the history of Canada as disclosed by recent field work. The geology of Canada is usually admirably displayed as the canoe threads the intricate waterways of sprawling lakes spilling over from one irregular basin into another. As apparently hopeless confusion is methodically arranged, the ground plan of vanished mountains begins to show itself. The typical arrangement is that of rounded or oval batholiths of gneiss or of granite merging at the edges into gneiss with schists, dipping steeply away from them on all sides. "Of what kind," asked the professor, "were the mountains erected on these bubble-like foundations of gneiss set in meshes of schist?" In many places they do not seem to have formed continuous ranges such as those of the Rockies, but rather groups of domes of various sizes. Some curious dynamical problems are involved in the raising of the domed mountains. It is conceivable that fluid lava could be forced by the unequal pressure of shifting mountain blocks through a suitable system of pipes into cisterns, so as to form lacolithic domes, but no such mechanism seems possible with batholiths. The granite of the batholiths was plastic rather than fluid, as shown by its having been dragged into the gneissoid structure. The areas affected covered sometimes 1,000 square miles. We know of no system of dykes to serve as pipes or passages, of no solid floor beneath, of no faulted blocks to provide the pressure. It is generally assumed that the protaxial granites and gneisses in great mountain ranges have risen because of the relief from pressure beneath anticlines due to lateral thrust. It is doubtful if these irregularly-scattered ovals, sometimes thirty miles across, can be adjusted to any system of anticlines. The author proceeded to discuss a classification which was proposed by the American geologists for the Lake Superior region. This classification did not find complete favor, and a compromise system was proposed, and is now in general use in Canada. This compromise system the author has again modified, and for Canada proposes the following classification: Keweenawan, unconformity; Animikie, great unconformity; Upper and Lower Huronian, great unconformity; Keewatin; Laurentian = Post-Keewatin or Post-Huronian granite and gneiss. The president then proceeded to trace the history of the region during the successive periods suggested in this classification.

Improvements in the making of paper pulp from lallang grass have been invented by a planter in the Malaysian State of Negri Sembilan. Consul-General James T. DuBois, of Singapore, states that as the lallang grass grows in great quantities in some parts of the Federated Malay States much interest is being taken with a view to utilizing this grass as a marketable pulp. Investigations have not been favorable to the success of lallang as a paper-pulp produced when used alone, but in conjunction with different kinds of pulp it is believed that it will be marketable.

MODERN ROTARY STEAM ENGINES.*

SOME NEW FORMS OF PRIME MOVERS.

BY WARREN O. ROGERS.

IN Fig. 1 the engine is shown mounted on a subbase, to which the high-pressure and low-pressure cylinders are secured. Each cylinder is placed midway between two bearings. The shaft passes through the side covers with a free clearance. A cylindrically shaped rotor piston is eccentrically attached to the shaft and the weight of its projecting periphery is counterbalanced and each engine is counterbalanced within itself. The two cylinders are joined together, and the moving parts as a whole are balanced.

Fig. 2 is a sectional view through the center of the high-pressure cylinder. The shaft, where it passes through the side of the rotor casing, is made steam tight by packing boxes. The rotor piston is mounted on the shaft eccentrically, so that the projecting periphery of the rotor passes the inside wall of the casing with a clearance of less than one-thousandth of an inch on each side. This clearance space is made steam tight by a metallic strip of packing placed in a groove, and pressed outwardly by a flat spring.

Leakage of steam and excessive friction are prevented by a packing ring, contained within a packing ring. The overbalanced periphery is relieved of its extra weight by means of holes passing through the rotor from side to side, which connect depressions on each end of the rotor, and allow any leakage of steam to give equal pressure on both sides of the piston.

The hammer-shaped rider abutment is pivoted at the handle end by a hollow bearing passing through the side casings. This bearing is placed in direct line of resistance to the steam pressure, with the rider portion between the entrance and the exhaust port. The face of the rider is made steam tight by a metallic packing strip pressed against its vibrating radial surface by means of a flat spring.

Attached to the rider end is a hardened strip with a cylindrical toe. An intermediate metallic saddle plate, cast in a circular segment, is placed between the rider toe and the rotor. The saddle fits closely to the moving rotor, both being of the same radius, and is held in place by a radial arm hinged to the abutment bearing.

Attached to the handle of the rider is a pivoted pressure rod that enters the hollow end of a pressure piston which closely fits a cylindrical opening, in the outer space of which the steam pressure holds the entire mechanism against the periphery of the rotor.

The saddle has a tongue piece that projects into an opening of the entrance port and holds the rotor packing strip in place. It is far enough forward to form, while in operation, a leverage that prevents the back end of the saddle from being thrown up as the projecting end of the rotor piston revolves. The saddle glides over the surface of the revolving rotor with a rising and lowering rocking motion, while the rounded toe of the rider moves up and down with a constant pressure against the center of the rocking movement of the saddle. The saddle in turn is pressed against the rotor, thereby preventing the steam from taking the short passage from the entrance port to the exhaust port.

The port through which the steam enters is governed by a sliding revolver-barrel-shaped valve operated by an eccentric, which is attached to the main shaft outside the main bearings, thereby admitting steam once at every revolution of the shaft.

This valve closely fits into a cylindrical inner casing having steam ports near the front edge of the valve. The valve has holes passing through it lengthwise, which allows some of the steam to pass through and thus equalize the pressure at both ends of the valve, giving it a free movement while in operation.

This casing is entirely surrounded by live steam under constant boiler pressure. The steam enters the steam chamber behind the rotor, just as its projecting end reaches the bottom of the entrance port. The steam, being prevented by the rider abutment and saddle from passing directly to the exhaust, exerts its pressure in the space behind the rotor piston and forces the piston around. The steam is cut off when the rotor piston is half way to the exhaust chamber, and the expansion of the steam continues to force the rotor to the exhaust chamber, while the momentum continues the revolution of the rotor to the entrance port again.

The steam already in the cylinder continues to expand, and forces the rotor piston around until the expanded steam is released at the exhaust chamber,

* Reprinted from Power and The Engineer.

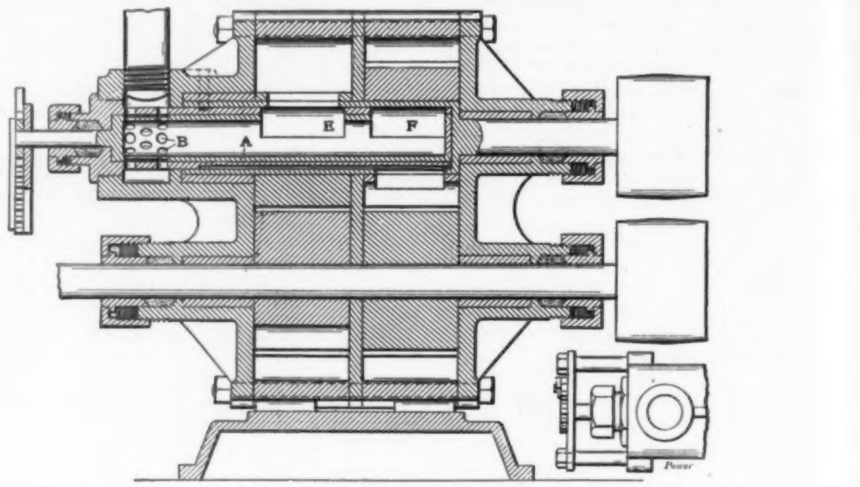


FIG. 4.—VERTICAL LONGITUDINAL SECTIONAL VIEW OF KNOWLES ROTARY ENGINE.

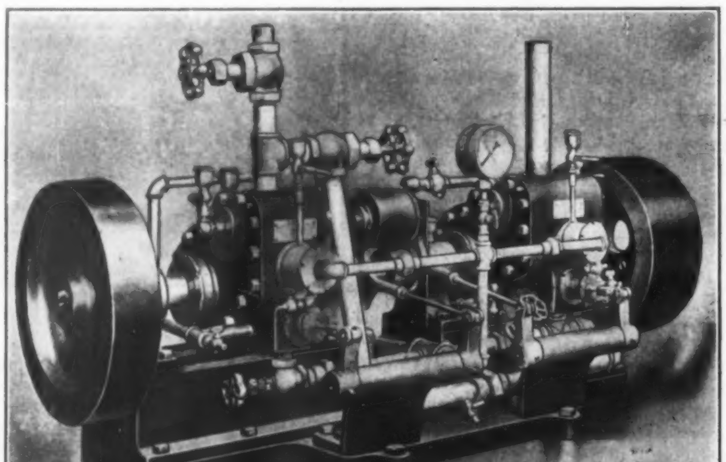


FIG. 1.—HARRIMAN ROTARY ENGINE.

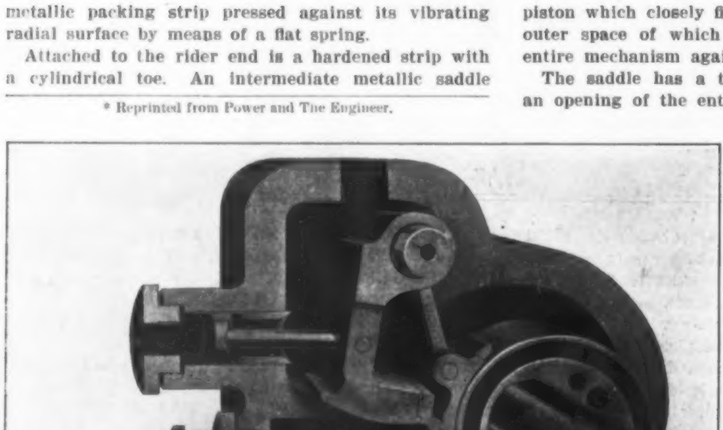


FIG. 2.—SECTIONAL VIEW OF HARRIMAN ROTARY ENGINE.

FIG. 3.—KNOWLES ROTARY ENGINE.

and then passes to the low-pressure cylinder through the exhaust port. The rotor piston continues its revolution under the acquired momentum, and under the alternate force from the low-pressure cylinder, until it again reaches the bottom end of the inlet port where the steam is admitted.

Having done its work in the high-pressure cylinder,

KNOWLES ENGINE.

This engine, Fig. 3, is the invention of John Knowles, Colorado Building, Denver, Colo. It consists of a pair of engines arranged side by side, each being provided with two intersecting cylinders containing rotary pistons co-operatively arranged, and having a driving shaft arranged axially through both the upper

7 shows a sectional view of the steam-inlet shaft, the piston being removed, as at *A*; a transverse sectional view of the same at *B*, and a side and end view of the steam-inlet sleeve upon which the steam-inlet shaft revolves, at *C*. A view of the cutoff-valve *D*, which is rotatively journaled in the steam-tight sleeve, is also shown.

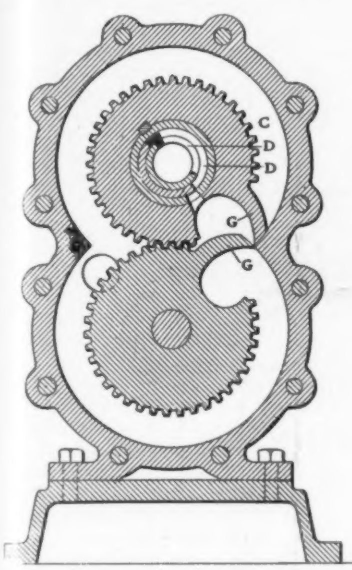


Fig. 5.—TRANSVERSE SECTIONAL VIEW OF KNOWLES ENGINE.

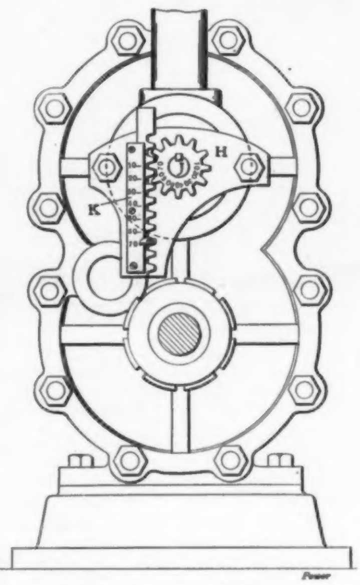


Fig. 6.—END VIEW OF KNOWLES ENGINE.

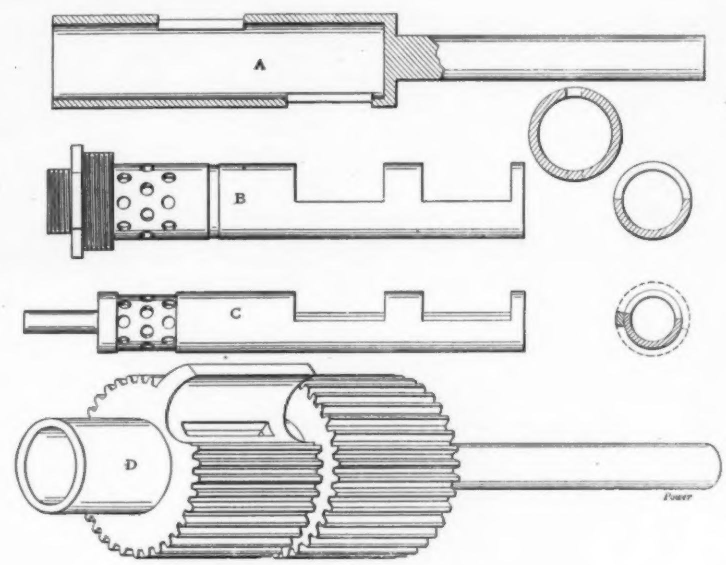


Fig. 7.—DETAILS OF VALVE AND ROTOR, KNOWLES ENGINE.

the steam passes directly to the low-pressure cylinder, where it again repeats the cycle described for the high-pressure cylinder.

The interior parts of the engine are lubricated by oil entering with the live steam, and also through

and lower horizontal cylinders and pistons of both engines. The pistons and shaft rotate in unison. The engine is also provided with an adjustable rotary cutoff-valve mechanism that will permit the steam to be cut off at different predetermined points or parts

The operation of this engine is as follows: The steam enters the hub of the forward cylinder head around the sleeve *A*, Fig. 4, through the steam-inlet apertures *B*, into the interior of the rotary valve, from which the steam is discharged through the ports

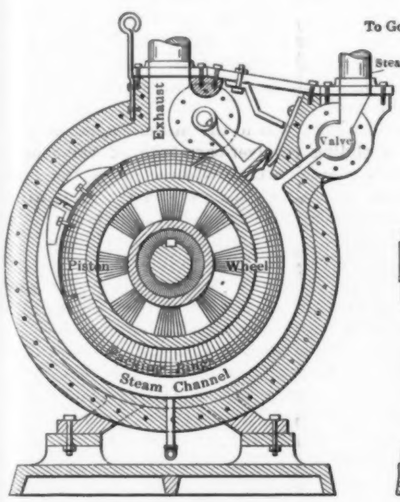


Fig. 8.—SECTIONAL VIEW OF SCHMIDT'S ENGINE.

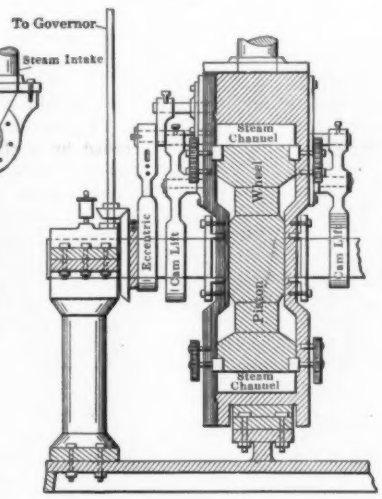


Fig. 9.—FRONT SECTIONAL VIEW.

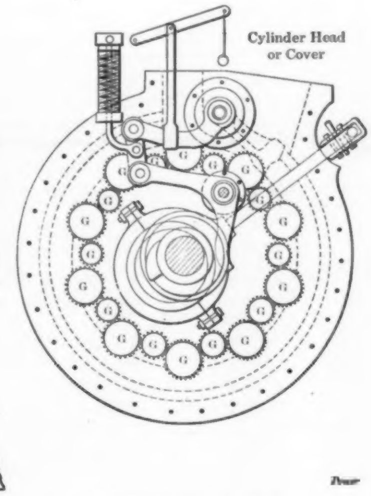


Fig. 10.—EXTERIOR VIEW OF CYLINDER HEAD.

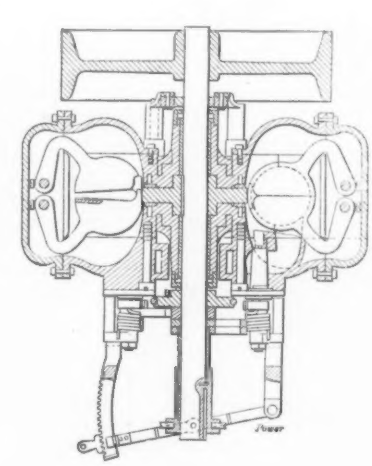


Fig. 11.—SECTIONAL VIEW OF ENGLUND ROTARY ENGINE.

the hollow shafting that passes through the handle of the rider abutment. It passes down through holes in the handle of this rider and through the rider itself to the rounded steel toe which presses on the saddle. It also passes through the holes in the hinged arm piece to the saddle. Tests made by Edward F.

of the revolution of the driving pistons in their respective cylinders.

In Fig. 4 is shown a vertical-longitudinal sectional view of this engine. Fig. 5 is a transverse vertical

D D, Fig. 5, to the port *E* and *F*, of the shaft, Fig. 4, as it rotates. The steam then passes into the cylinder and pushes against the piston arms *G* of the pistons shown in Fig. 5. This causes the two pistons to

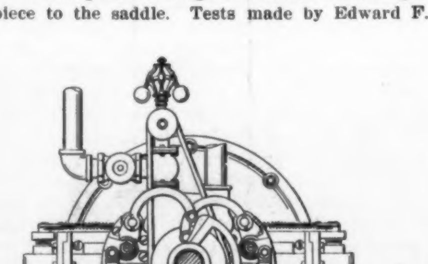


Fig. 12.—END VIEW OF ENGLUND ROTARY ENGINE.

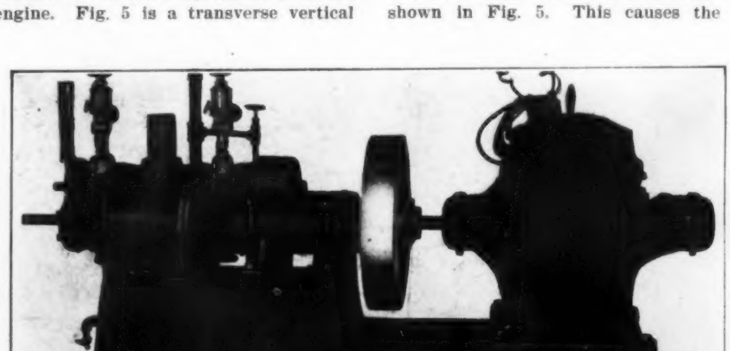


Fig. 13.—MOTSINGER ROTARY ENGINE.

Miller and Theodore H. Taft show the steam consumption of a Harriman 25-horse-power engine to be 31.02 pounds of steam per brake horse-power hour. This engine is manufactured by the Harriman Engine Company.

sectional view through the rear cylinder, showing the pistons in the position they occupy relative to each other immediately preceding the admittance of steam to the cylinder. Fig. 6 is an outside end view of the engine, showing the valve-governing gear. Fig.

revolve in their cylinders, the meshing of the gear teeth of the piston causing them to move in unison. The arms of the inlet ports of the valve and sleeve are such relative to the oppositely proportioned parts of the shaft, that the upper pistons and their

shafts have no dead centers when the valve is set to cut off at 70 per cent of the piston's rotative stroke, as one or the other of the parts of the sleeve and valve are open to the ports of the shaft at all times.

The point of cutoff is controlled by means of an index gear wheel *H*, Fig. 6, which is secured to the outer end of the valve stem. An index plate *J* is secured to the front of the cylinder head. A slidable tooth bar *K* meshes with the gear *H*. The upper end of the sliding bar *K* is attached to a governor which automatically moves the sliding bar up and down as the speed of the engine increases or decreases. This movement is transmitted to the valve, giving it a semi-rotary motion, and in so doing determines the point of cutoff. This cutoff varies from 10 to 70 per cent of the operative stroke of the engine.

SCHMIDT'S ROTARY ENGINE.

A patent for a rotary steam engine has been granted to Rudolph F. Schmidt, Cincinnati, O. An end view of the engine, with the cover removed, is shown in Fig. 8. A long-hinged abutment which provides for swift and easy passage of the piston head under the abutment is made hollow on top in order to reduce the weight. The piston wheel is mounted on the main shaft and fills the center of the cylinder, leaving a shallow steam channel surrounding the wheel. The piston head is made in two sections, interlocked and curved on both ends, which allows a back and forward movement under the abutment without the aid of cams and levers.

Split packing rings, which are not supposed to give at high pressure, or cause great friction on the sides of the piston wheel, come level with the rim and partly extend into grooves in the sides of the cylinder, into which they are forced to prevent leakage, and partly into corresponding recesses of the piston wheel, thereby protecting the abutment from wear while the wheel is in motion.

An end spring plate facing against the abutment the full depth of the channel prevents entering steam from passing to the exhaust opening, and a safety spring plate above the abutment counteracts upon it to prevent injury to the engine. The exhaust is always open, thus providing a clear outlet. The drain pipe at the bottom of the casing is to drain the cylinder from condensation before starting the engine.

Fig. 9 illustrates a front sectional view of the cylinder which is composed of three parts: the main body, the cover or cylinder head, and the base. The piston shows recesses on both sides of the wheel cover and side of casing, which are for packing rings. Interlocked gearings with set screws on a line with the packing ring and arranged for adjusting the ring evenly into the recesses of the piston wheel are also shown.

Fig. 10 illustrates the cover or cylinder head, showing the levers which counterbalance the weight of the abutment and thus lessens the strain and jar due to the swift contact with the cam. The eccentric for operating the steam valve, and special pin for the bell-crank levers are also shown.

The hinged lever or shifting device is for use in raising the abutment out of contact with the piston head while it is in motion, which is essential when reversing the engine or the position of the cam wheel.

Each cylinder is equipped as a complete engine, but to eliminate a dead-center position with cutoff at less than one-half stroke, three cylinders are used; with cutoff at one-third stroke, four cylinders, and for full expansion of high-pressure steam, five cylinders are used.

The long abutment makes a swift passage of the piston head possible and prevents the steam from passing to the exhaust outlet. The piston head is fastened to the piston wheel, which is keyed to the main shaft upon which, on the outside of the casing, are cam wheel and levels which are attached to the pin of the abutment for the purpose of raising the abutment in immediate advance of the piston head and thus prevent violent contact. There is also an eccentric to operate the valve. The valve does not connect with the exhaust outlet, and allows a cutoff of steam at any point of piston travel, thus utilizing the expansion of the steam. The entering steam, encountering the resistance of the abutment, advances the piston head, and after cutoff the steam is released when the piston passes under the exhaust opening.

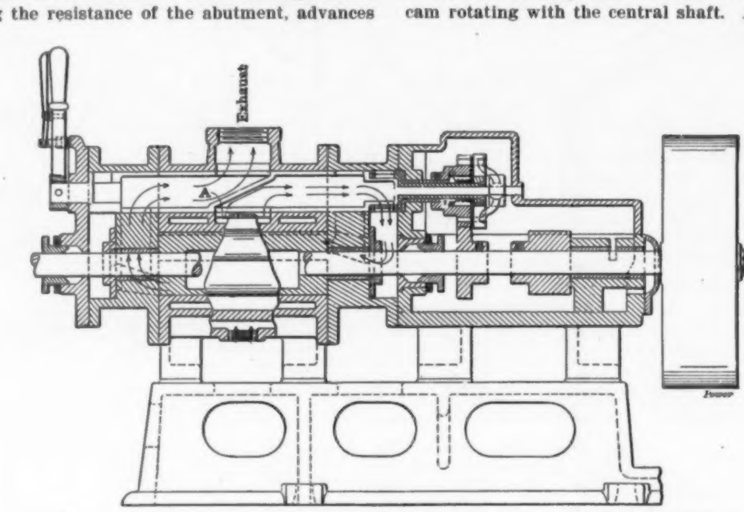


Fig. 15.—SECTIONAL VIEW OF MOTSINGER ROTARY ENGINE.

A single-cylinder engine of this class requires a flywheel to bring the piston head, when stopped, to a port opening, but with a duplication of cylinders on one shaft, one piston head on each, and each piston wheel arranged to preserve balance and take steam, the dead center is eliminated.

Large port openings, in proportion to the piston surface, are provided, which allows a quick response to the load.

ENGLUND ROTARY ENGINE.

According to The Engineers' List, this engine is the invention of Albert O. Englund, Wayne, Kan. In its general features, the engine comprises a fixed annular cylinder having a piston moving therein, which projects outward from a central shaft. Within the cylinder are one or more gates which, when closed, form abutments, or cylinder heads, and which, when open, permit the passage of the rotary piston and then close.

As will be seen from Fig. 11, the cylindrical cylinder shell is mounted on a base provided with suitable bearings for a central rotary shaft. Projecting outward from the shaft is a collar which carries the piston disk.

The cylinder is slotted on its inside circumference, and the collar on which the disk is counted fills this slot while suitable packing rings prevent the passage of steam out through them.

At diametrically opposite points on the cylinder are located gate chambers, containing the gates.

Communicating with the gate chambers on either side of the gate are steam-inlet and exhaust valves. These are operated by rock shafts, see Fig. 12, which are actuated by inwardly projecting curved arms, having antifriction rollers at their ends. These are engaged by cams mounted to rotate with the central main shaft but so mounted that they may be shifted with relation to each other to control the time of opening and closing the inlet and exhaust ports. The lift of these cams, and the initial opening of the valves are accomplished by means of a hand lever, engaging with a movable sleeve extending across the cylinder. These gates each consist of two semi-disks, each half-disk being mounted on the end of a curved arm, which in turn is mounted on and turns with a vertical rock shaft. The two rock shafts which together actuate the two halves of the gate are geared by sectors to move together though in opposite directions. Projecting rearward from these rock shafts are arms which in turn are connected by a system of levers and rocking bars which are acted upon by a cam rotating with the central shaft. As the shaft and cam rotate under the action of the circularly moving pistons, the gates on one side or the other are opened to allow the passage of the piston, or closed after it to form the cylinder head.

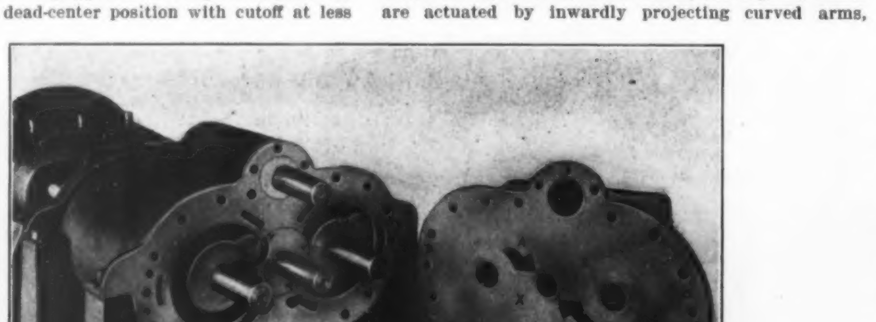


Fig. 14.—VIEW OF ROTORS AND PORTS IN CASING, ALSO PORTS IN HEAD.

Mounted on this central shaft is a pulley which, by means of a belt, drives a governor for controlling the inlet of steam to the cylinder.

When steam is admitted to the cylinder, it passes into one of the valve chambers and through one of the partly opened gates, the other gate being closed. The steam impinges on the rear face of the piston, driving it forward. As the piston travels forward, the gate behind it closes, and an inlet valve opens just forward of the closed gate, while the exhaust valve of the gate ahead opens. This valve closes just before the piston reaches it, and the second or right-hand gate opens. After the piston passes the open right-hand gate and the inlet port of that gate is opened, the right-hand gate closes. After the piston has passed the right-hand gate and the inlet behind it has opened, the left-hand gate closes and the left-hand exhaust is opened before the moving piston.

In the first half of the revolution, the left-hand gate closes shortly before the right-hand gate opens, and in the second half the right-hand gate closes shortly before the left-hand gate opens; thus each gate closes with pressure on both sides. While the gates are opening they are not under pressure.

If the load on the engine does not require the piston to operate under a direct head of steam during its whole travel, the engineer moves the cam-adjusting lever rearward, and thereby holds the inlet port valves closed for a longer period than when the steam is not being used expansively. All the valves are of rotary type and are actuated by cams. The two sides of the gate move in gate chambers or slideways which hold them rigidly in alinement with each other.

MOTSINGER ROTARY ENGINE.

This engine is shown in Fig. 13, direct connected to a small direct-current generator. The details of construction are shown in the accompanying illustrations.

The engine consists of three cast-iron rotors, as shown in Fig. 14. The center rotor is made with a round groove, and the two outer rotors each have a projecting tooth with a round face, which fits into the groove of the center rotor. These rotors are connected by means of gear wheels which are secured to one end of their shafts and cause the middle rotor to turn at such a speed as to permit the tooth of each outer rotor to fit in the groove. By setting the rotors 180 deg. apart, the vanes of both outside rotors may alternately use the groove in the middle rotor.

These rotors are incased in a cylinder having three bores whose centers are in the same horizontal plane. The radii of the outside bores are as much greater than the radius of the middle bore as the height of the vane; the outside bores cut into the middle bore a depth equal to the difference of their radii. Placed in proper bearings of the heads covering the ends of these bores, the three rotors lie in contact with each other their entire length, forming two steam-tight chambers swept by the rotating vanes on each side of the center rotor. Both heads are cast from the same pattern and their steam chests each contain three chambers communicating with the ports that lead to and from the engines.

Fig. 14 shows the arrangement of the three rotors, also the steam ports.

The tops of the rotor vanes are made steam tight by fitting T-shaped packing strips into T-shaped grooves, allowing a little space at the bottom for movement and wear. Small coil springs inserted beneath these strips and the centrifugal force of rotation hold them tight against the surface of the cylinder. The middle rotor is packed in the same way by the use of four packing strips set 90 deg. apart so that there are always two of them (one above and one below), doing service in preventing steam from passing from one engine to the other. The ends of the cylinders can be similarly packed, but as the ends of the rotors fit snugly against the heads, and there is so little wear, it is said that there is no need for packing. To take up the wear of the bearings and prevent any possible leakage between the rotors into the exhaust opening, a spring gib is used against a split bushing. It is adjusted and held tight by a set screw and jam nut against each bearing of the outside rotors.

Since both heads are alike and face each other on the engine, the positions of the ports *A* and *B*, Fig. 14, will be reversed, and when the head, shown removed, is put in place, if one could look through the engine toward the flywheel, the far port for the left-hand engine would be exactly opposite the upper port *X*. The left-hand rotor is shown in position to take steam at the far end of the cylinder, and when it has made almost a complete turn will exhaust through port *B* of the near head below the plane of the centers of all the rotors. Looking through the right-hand engine one would see the far port opposite lower *X*, and the right-hand rotor would be shown as having gone half a turn since taking steam and would exhaust through the near port *A*, above the plane of centers of all the rotors.

Fig. 15 is a sectional view through the center line of the engine, showing the design of the valve and the passage for the steam to the exhaust.

The governing device, Fig. 16, consists of a central stud on which a gear revolves, driven from a second gear secured to the shaft of the center rotor. To the top gear are hung two weight arms, which are kept in position by means of a spring fitted to each. To the pivoted end of each weight arm is secured a segment and gear wheel which mesh with a gear fitted to the valve stem of the engine. As the speed of the engine increases or decreases the governor weights are moved in or out, and the gear segments, moving with the weight arms, turn the valve which cuts off the steam, earlier or later, as the speed of the engine dictates.

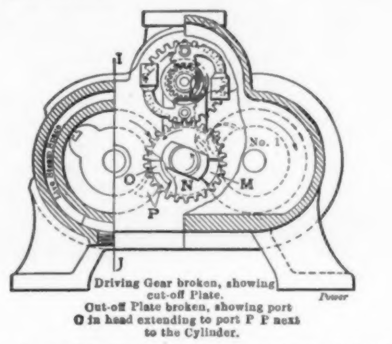


FIG. 16.—GOVERNOR AND VALVE GEAR.

Steam enters the engine and passes to the port that registers with the two middle ports of the reverse valve shown at *A*, Fig. 15. Directly opposite and below in the live-steam port is the exhaust port. It also registers with the middle port of the reverse valve. The middle ports of the reverse valve are separated by a partition which makes the port on one side communicate with one head, and the port on the opposite side communicate with the other head, so that when the port is open for live steam to enter one end of the engine, the other port is open to receive the exhaust from the other end. The inlet and exhaust ports are on the same side of the valve but at opposite ends. The exhaust ports always open both behind and in front of the cutoff plate, makes a free exhaust possible.

At the near end of the valve, Fig. 14, are shown three inlet ports. The largest port opens into the steam chest in front of a cutoff plate, and steam coming through it is fed to each engine alternately by the port in the revolving cutoff plate. The two slot-like ports open behind the cutoff plate to both engines where there are no dead points. The ports in the heads being on opposite sides, the engine is reversed by a half turn of the valve handle. When the reverse handle is perpendicular all steam is shut off both engines, but if moved either way to a point within 15 deg. of the horizontal, the two ports behind the plate will open to both engines where there are no dead points, and the engine will start with any load it can pull. Pushing the handle completely home to its resting lug, the ports beneath the plates will be closed and the engine will run on the "economic" cutoff plates.

The exhaust is always open in front of the steam-driven vanes. The ports in the heads, Fig. 14, are cut the shape of a stylish shoe, *A* inverted and *B* upright. The toe part of the shoe is the main exhaust for the steam behind the vanes, but the heel part opens into the groove of the middle rotor, and as this groove naturally exhausts first, this heel part of the port serves to admit steam at the earliest point desired when running one way, and to let out the last bit of water or steam contained in the groove as the vane dashes quickly by in the opposite direction.

This engine takes steam once every revolution, and exhausts but once. Steam pressure is maintained during almost a complete revolution.

The equal circular bodies of the rotors are cored to balance by taking out metal from the side the vanes are on and leaving in metal on the grooved side.

This engine is made by the Motsinger Rotary Engine Company, Greensburg, Pa.

THE GABET TORPEDO.

CONTROLLING A TORPEDO BY WIRELESS ENERGY.

BY LUCIEN FOURNIER.

ONE of the most interesting problems in the wireless electrical control of machinery is that of the steering of torpedoes. Essentially technical in its elements and data, this problem has a practical side of

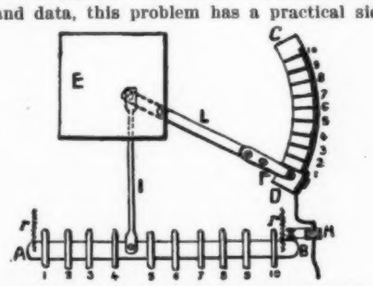


FIG. 2.—DIAGRAM OF RADIO-COMBINATOR.

startling character. A great warship, which has cost ten million dollars and five years work to construct, and which carries a crew of nearly a thousand men, is entirely at the mercy of one of these diminutive engines, directed against it by a human will from a distant and perfectly safe place, which may destroy the great vessel and all its crew in a few seconds. One feels almost tempted to beg the inventors to give up the project.

The solution of the problem is particularly delicate because the aerial electric waves which form the bond of connection between the destroyer's will and the engine of destruction are also, or at least have been hitherto the best protection of the warship, which can always frustrate the plans of the enemy by emitting other waves which will annul the action of those employed by the enemy, and will thus make the attack futile.

This condition will not persist if the numerous inventors now at work on the problem succeed in their attempts. M. Gabet appears to be the most successful of these inventors. The experiments which he has made on the Seine have demonstrated the great facility of evolution of his torpedo in a narrow stream, obstructed by numerous bridges, but he has yet to apply the crucial test of operating at sea in the presence of disturbing electric waves. This test would already have been made if last winter's flood had not damaged a portion of the apparatus. Let us hope that complete success may crown Gabet's efforts and that he will give the French navy a new weapon, which will compensate in some degree the injuries which it has sustained in recent years. The inventor has given the latter a few hitherto unpublished details of his invention, which are set forth below. The most important features are still kept secret.

The torpedo is of a form very different from that of the torpedoes now used by the navies of the world. It consists of a cylindrical body, sharply pointed at both ends, which contains, in addition to the explosive charge, the motor and all the mechanical and electrical organs used for propulsion and for wireless electrical control with the exception of the screw propeller. Above, and attached to the main body of the torpedo by vertical rods, is a similar, but slightly smaller, pointed cylinder, which serves as a float. This float in turn is surmounted by the supports of the antennæ by which the electrical waves are received. The entire weight of the torpedo is about four tons, nearly one-half of which is represented by the motor of 200 to 300 horse-power.

The most important organ of the torpedo is the receiving device called the tele-commutator, but this alone would be unable to solve the problem of wireless control, which requires special apparatus for the protection of the receiving instruments, from the disturbing action of the sparks produced by the other instruments inclosed in the same hull, and especially from that of waves emitted intentionally or accidentally by vessels or coast stations in the vicinity. The inventor still keeps secret the methods which he uses for this protection.

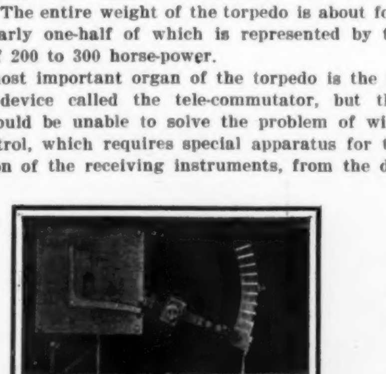


FIG. 1.—INTERIOR OF RADIO-COMBINATOR.

The principle upon which the operation of the apparatus depends is that of delayed contact, which is employed in one way or another in all devices for wireless control of machinery. When the signal sent

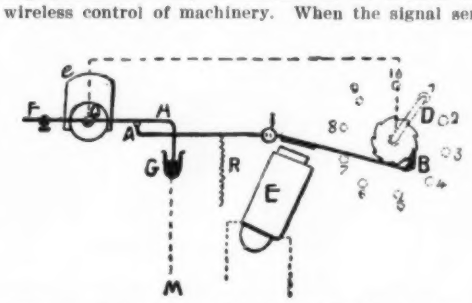


FIG. 3.—DIAGRAM OF TELE-COMMUTATOR.

by the transmitting station has been received by the apparatus in the torpedo, the machinery of the last puts itself in readiness to act, but does not act immediately. In the Gabet torpedo, the delay thus introduced amounts to about 2½ seconds.

A device used at the transmitting station, which is called a radio-combinator (Fig. 1) relieves the operator from the material details of manipulation. It is merely necessary to press a key in order to operate at a distance the organ corresponding to that key. The radio-combinator, which is about 9 inches square, has a keyboard resembling that of a piano, containing ten keys numbered from one to ten. These keys rest upon a horizontal bar *AB* (Fig. 2), which is rigidly connected with a rod *I*. This rod operates a lever *L*, which turns round a pivot at *O*, and is terminated by a contact spring *F*. As the lever turns this spring moves over an ebonite sector *CD*, in which are inserted ten strips of copper, numbered to correspond with the keys. The contact of the spring with any of these copper strips completes an electric circuit. The current reaches the apparatus through the axis of the lever. A circuit is also closed through the contact *H* when the lever is in the position indicated in the diagram, to which it is brought, when no key is pressed, by the operation of the springs *rr*, acting on the bar *AB*.

The keys act upon levers which move the bar *AB* vertically through distances varying in proportion to the number of the key which is pressed, and bring

the contact spring *F* of the lever *L* to the copper strip having the same number as that key. When the key is released the bar and lever return to their zero positions and the lever in its descent makes a number of contacts corresponding to the number of the key used.

This very simple apparatus can be used by an unskilled operator, who has only to press the keys in succession as he is directed by the chief operator, who is thus allowed to concentrate his attention upon the luminous signals which appear upon the float of the torpedo and indicate the operation of the apparatus on board.

An instrument called a tele-commutator (Figs. 5 and 6) is connected with the wireless receiving apparatus of the torpedo. The tele-commutator, is mounted on a vertical board, measuring 9 by 15 inches. It contains a lever *AIB* (Fig. 6), which turns about a pivot at *I* under the action of an electro-magnet *E*, which forms part of the circuit of the wireless receiving apparatus. The end *B* of this lever carries a pawl which causes a ratchet wheel to advance by one tooth every time the circuit is closed. The shaft of this wheel carries a contact spring *D*, placed behind the board. As the wheel turns, this spring makes contact successively with a number of metallic segments, which correspond to the copper strips and keys of the radio-combinator.

The problem to be solved consists in bringing the spring *D* to the segment corresponding to the desired maneuver, without making contact with the intermediate segments. This result is obtained by means of the retarding apparatus, which is attached to the end *A* of the lever. This apparatus contains a lever *FOH*, pivoted at *O*, one end of which dips into a mercury cup *G*. When the electro-magnet *E* is traversed by a current, the arm *A* of the lever *AIB* rises and carries with it the lever *FOH*, breaking contact with the mercury. The lever *FOH* then falls slowly by its own weight, occupying 2½ seconds to re-establish contact with the mercury. This retardation is produced by a little windmill escapement, connected with a train of wheels which is set in motion by the weight of the lever *FOH*. During this interval of 2½ seconds, therefore, the contact spring *D* may be caused to pass over any or all of the ten segments by the operation of the lever *AIB* and the electro-magnet, without transmitting any current, as the circuit is broken at *G*. Hence, wave trains separated by intervals of less than 2½ seconds do not affect the controlling apparatus. The currents are sent out by the transmitting apparatus and are received by the wireless detector, but they have no effect upon the tele-commutator, unless the spring *D* remains in contact with one of the segments for more than 2½ seconds.

The circuits established in this manner are completed by magnetic couplings, by means of which the motor of the torpedo governs the movements of the rudder and the reversible propeller. The lever *AIB* (Fig. 6) also controls a system of eclipses of lights carried on the masts of the antennæ. These eclipses indicate to the distant operator the reception of his commands, and the method of retarded contact enables him to retract an order before it has been executed by the torpedo. This method of optical control is used in daylight as well as at night. It is superior to the system of signals employed in other apparatus of this character. The light is produced by an oxy-acetylene flame with an incandescent pastille, and has a power of 20,000 candles.

The Gabet torpedo carries an explosive charge of 2,000 pounds, which is seven or eight times greater than that of the torpedoes now used. The explosion of such a charge would immediately sink any warship, and the exclusive employment of this engine of destruction by the French navy would remedy, to some degree, the increasing relative deterioration which has caused France to sink from the second to the fifth rank among the naval powers of the world.—Cosmos.

A note in the Ironmonger refers to the use of acetylene as an illuminant in Turkey. Until the reestablishment of the Constitution calcium carbine was forbidden in Turkey, but since liberty in its use has been allowed, several persons have adopted acetylene as an illuminating agent. In several cases imperfect generating apparatus has been bought, while not infrequently installations have been made too hastily, so that considerable care should be exercised by those wishing to do business. Until the present the Americans have done most business, but many of their generators have been too complicated for Turkish workmen to set up and subsequently work. But if constructors who have good forms of apparatus would send experienced representatives having a full knowledge of the subject, there should be a good prospect of business and a considerable movement in favor of acetylene could be created in Turkey. Among applications capable of considerable development, mention may be made of the lighting of villas, shops, and hotels, as well as that necessary in mines, at ports, and on railways.

ELECTRICAL NOTES.

A French patent has been taken out by the Westinghouse Metal Filament Lamp Company, Ltd., of England, covering a method of decarbonization of metallic filaments for electric incandescent lamps. The filaments, consisting of powdered metal and a binding material, either previously carbonized or not, are placed in suitable receivers, exposed to a high vacuum, and simultaneously to a high temperature, by heating the vessel externally. In this way the carbon is said to be practically eliminated, probably by electrical disintegration. The vacuum must be very high as it was found that at pressures of 0.2 to 0.5 millimeters of mercury the carbon was not eliminated from filaments containing tungsten and carbon even at 1,500 deg. C. As an example, tungsten filaments containing 1.5 per cent of carbon were heated in a high vacuum for 1 hour at 800 deg. C. This reduced the carbon to 1.23 per cent. After heating for a further hour at 900 deg. C. only 0.57 per cent of carbon remained; after a further 1¼ hours at 1,000 deg. C. there remained 0.35 per cent of carbon, after another hour at 1,100 deg. C. 0.06 per cent and after finally heating for a further hour at 1,200 deg. C. only 0.04 per cent of carbon remained, or possibly even less than this. The vacuum employed was 0.056 millimeters of mercury while cold, but dropped to 0.2 millimeter of mercury while heating, rising again to the former value on cooling.

An electric railroad line of short length, which has lately been constructed in the Mont Blanc region, presents considerable interest. The starting point of the line is at Martigny, in the Rhone valley, and this locality lies on the Swiss Federal railroad, between Lake Geneva and the Simplon line. Martigny is one of the leading centers for electro-chemical industries and there are a number of such plants in the region. It is also the starting point for the electric railroad running to Chamonix and Mont Blanc. The new electric railroad follows in part parallel to the St. Bernard route and runs in the valley of the Dranse after leaving Martigny. Unlike the Chamonix line and the two other lines, Viege-Zermatt and Monthey-Champery, which are organized as tourist railroads, the new road is of standard gage. The electric line runs in valleys or gorges in the mountains and mounts up gradually to the terminus at Orsieres, which lies at 905 meters (2,969 feet) above sea level and at 12 miles distance from Martigny. There are three metallic bridges upon which the road crosses the river in various places, besides seven tunnels of 400 feet and under, and several masonry bridges and viaducts. At Orsieres there is erected a large depot for the terminus. It is proposed to run a branch line in order to make connection with the extensive electro-chemical plant belonging to the British Aluminium Company, which lies in the neighborhood of Orsieres. Work on the present line was commenced in 1907, and it began running about the first of September of this year.

TRADE NOTES AND FORMULÆ.

Cement for Enamel Dials.—Scrape pure wax and mix with an equal quantity of zinc white. The mass must be melted in a clean vessel over a spirit lamp and allowed to cool.

To Age Pewter Articles.—H. Stockmaier recommends brushing with chloride of antimony solution, which must be allowed to dry and carefully rubbed off. Finally rub with oil. Before treatment the articles must be perfectly freed from grease.

Fulminating Primary (For Needle Fire Locks).—Gottlieb's mixture consists of 4 parts chlorate of potassium, 2 parts sulphide of antimony, 1 part sulphur. Each ingredient is to be separately reduced to the finest powder, then mixed. The mixture is placed wet in the cartridges and dried at about 87 deg. F.

To Harden Bricks of Lime Sand.—Sand, crushed quartz, or other kinds of stone is mixed with lime powder, or powdered hydrate of lime, and a little water. The mixture is pressed in molds, allowed to stand three to ten days, then placed in water in which some lime or calcium salt has been dissolved. The water is heated to 200 deg. C. After two to six days they will be hard.

Ignition Strips (Non-Extinguishable by Wind. According to Bardet and Cottette).—Sheets of paper, thin cardboard, or wood are saturated in a solution of saltpeter, to which any substance that diffuses in burning, an agreeable odor, may be added. The leaves are then dried, and between each two leaves a thin layer of a gum mixture containing phosphorous is spread, a space being left free to hold them by. To the mixture a non-combustible substance, like powdered glass, fine sand, etc., is previously added. When dry, cut them up and coat them with varnish.

Tin Ashes (tin putty) is produced by subjecting molten tin to great heat and constantly skimming off the film of oxide that forms. The oxide mass obtained is ground and precipitated to separate the tin putty from the unchanged metal. For the purpose of making enamel, for which the tin putty is largely used, the presence of oxide ~~of lead in most cases~~ has no ~~deleterious~~ effect. Inasmuch as the tin oxidizes much more rapidly if lead be present, an alloy of 9 parts of tin and 1 part of lead is usually employed in making the putty, and a product is thus obtained that contains the necessary quantity of lead oxide.

Fire-Lighters.—Melt in a capacious kettle rosin of the lowest quality, heating it to such a degree that it begins to smoke. Then, gradually, so much coarse sawdust and small wood chips are mixed in until a mass is produced which, while warm, can be molded. The contents of the kettle are then rolled out on a stone slab into cakes 1½ to 2 centimeters thick, and with the aid of a knife, previously heated, cut into pieces 4 to 5 centimeters long and 2 centimeters wide. One of these lighters, touched with a burning match, will blaze up immediately, and will suffice to ignite coal.

Enamel Plates for Dials.—Thin sheet iron is cut into the desired form and pressed, the edges being slightly bent over. The plate must be cleansed chemically. The enamel mixture is prepared as follows: Twelve parts of white lead, 2.5 parts of arsenic, 8 parts of crystal glass, 3 parts of saltpeter, 6.75 parts of borax, and 2 parts of flint stone are ground, mixed, and melted together, and while still hot, chilled in cold water, crushed, washed and dried. The iron plates are spread with it and placed in a muffle, while the lettering and design are executed as usual. If we desire, however to impress them on cold enamel plates after having made an impression from the engraved plate in soft black enamel first transfer it to paper and then retransfer it, after which the article must be returned to the muffle.

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